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STACKS IN READING ROOM.

THE NEW BUILDING.

NEW MASSACHUSETTS STATE LIBRARY BUILDING, AT BOSTON, MASS.

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We present in this issue, on first three pages, engravings illustrating the new extension to the Massachusetts State Capitol at Boston, Mass. The corner stone of the old Capitol building, a view of which can be seen at the left of the picture, was laid on July 4, 1795. This building, usually spoken of as the "Bulfinch building," derives its name from the fact that Bulfinch, the first and one of the greatest American architects, designed it, and it has always been considered his masterpiece. The facilities of this building having been inadequate for many years, it was decided that the sadly needed room for the various departments of the State government be enlarged, and in 1889 the construction of the extension was authorized, and land was taken for the purpose in the rear of the Capitol, on the north slope of Beacon Hill. The corner stone of this building was laid with appropriate exercises by Gov. Ames, on December 21, 1890. The design was intended to harmonize with the Bulfinch front, and this idea is carried out in detail; but when you take into consideration that the new structure is more than twice the size of the Bulfinch building, you will readily see that it greatly dwarfs the latter, and that the effect sought has not been materialized. When the commissioners in charge of the construction in 1894 realized this defect, they very rapidly urged the demolition of the old Capitol building and to construct an entirely new one. This proposition naturally raised an indignant and universal protest throughout the commonwealth, and when an attempt was made to pass a bill through the Legislature to demolish this old Capitol building, rich in its style of architecture, with its colonnaded front and gold crested dome, standing as it does with historical interest upon a site overlooking the famous Boston Common, and making a that has been devoted to this work in composition, modeling and ornament can safely be called a classic piece of architecture with Romanesque feeling. The interior of the extension is pleasant, cheerful, well ventilated, and convenient. It contains the various administrative and executive departments of the commonwealth, and includes two handsome halls, that of the House of Representatives and the State Library, besides various committee rooms. The Senate remains in its chamber in the old building. The new Hall of Representatives is a handsome and richly decorated room, considerably larger than the old hall. The amphitheater shape, with its domed ceiling, lends itself well to fine decorative effects. The treatment is in the Italian Renaissance. Some of the prominent features of the scheme are the names of fifty-three men, prominent in Massachusetts history, inscribed in the frieze, beginning with John Carver and ending with Phillips Brooks. The names of the counties in the stained glass skylight, and the symbols of statecraft, law, commerce, science, industry and art that occupy panels in the coning and elsewhere, are also good features. Five large panels on the wall are intended to be occupied by decorative pictures representing events of Massachusetts history. The next department of importance is the State Library room, of which we give illustrations. Owing to the modern architectural effort being toward permanency, a demand has necessarily risen for fireproof interior fixtures, and if perfect security is to be obtained, not only must an apartment be fireproof, but also all its fixtures and its furniture, its connecting doors, interior trim and protecting shutters. Up to a comparatively recent period, these could not be secured of non-inflammable material, except at a large cost and in an unattractive form. The question in regard to the safe custody of the public records has become a grave necessity, and while considerations looking toward their longevity are justly

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picture which is dear to the heart of every true Bostonian, it was rejected by the Legislature, and the patriotic sentiment of the commonwealth won a victory over that of vandalism; hence the preservation of the old State House. There is a strong feeling that the reconstruction of the old part, made necessary by new conditions, should proceed with the most thoughtful regard for the spirit of Bulfinch's historic design, while making such changes as are essential to protect it against any ill treatment or injurious effects. The new extension which we present, and more particularly use as an illustration, is constructed of yellow brick, with white marble trimmings, simulating the familiar yellow and white of the colonial style. The underpinning is built of rock faced stone, the first story of dressed stone, and the remainder of the structure of brick, while the whole is surmounted with a massive frieze and balustrade. The only necessary requisite in a building of this character is the necessary apartments and their respective dependencies, and in the present case the actual and most essential requirements have been secured, and while the architecture is of a classic order, it is of the simplest expression; and how very effective an expression it is, when you take in consideration that the building was designed in keeping with the old building, and the general scheme of style and color is carried out with consistency to the last detail. The absolute plainness of the basement, except the outlying porches, the treatment of which is still severe, gives value to the arcades above, which is still further enhanced by the absolute plainness of its inclosing wall. The highest merit of the detail is that all of it tends to promote a high expression, and is far more valuable in its place, owing to its proper adjustment, which has been studied with complete success with reference to its situation and material. The outcome of the study recognized as of such importance as in some cases to be prescribed by statute, the prime factor for their safety still remaining for absolutely safe quarters for their custody and protection. The commission of experts having had these ideas in consideration, they adopted a basis upon which such a means could be materialized, and it does so conform in every respect. As an example of perfection in metallic building for interiors, we present a few specimen illustrations of the interior of the new State Library, one of which is an interior view of the reading room, delivery counter, desks and stack work, of which a glimpse is shown through the opening at end of room, this metallic work being of the highest order. A more detailed view is given of the alcove cases, which are built up of steel plates, ornamented with solid bronze ornaments and mouldings, fitted with marble base, and the Fenton system of adjustable library shelving. The last view is taken from the gallery in the stack room, and presents what the Fenton Company claim as one of their most important products, a perfect system of metallic library stack work, embodying all the points of lightness, ventilation, strength and utility, which were called for in the specification of twenty-one requirements as the essentials in a perfect system of library stacks. This metallic work must come with peculiar interest to architects and the building trades who have in consideration works of this character. The metallic work in this building has cost $125,000, and it was designed and built by the Fenton Metallic Manufacturing Company, with general offices and works at Jamestown, N. Y., and a New York office at 621 Broadway. The Capitol has one of the finest heating and ventilating plants in the world, constructed according to plans under Prof. S. H. Woodbridge, of the Massachusetts Institute of Technology. Another feature of particular interest is the lighting with electricity, furnished by a large isolated plant. The library stack room is splendidly lighted by a system that is certainly unique. Each tier is lighted by turning a switch. In the usual system of lighting library stack rooms, the turning on of the current lights the lamps overhead, but in the State Library the wiring is done so that when the current is switched on the lamps underneath the glass floor are also lighted as well as those above. Thus the light shines up through the glass floor, rendering access to volumes on the lower range as easy as those in the middle. Those who have had occasion to use libraries which have been poorly lighted will appreciate this convenience. The buildings will have properly laid out parks surrounding same when completed, and which will add much value to the picture presented.

Our engravings were made direct from photographs of the buildings, taken specially for the Scientific American.

EXPERT TESTIMONY.*

By William P. Mason.

It will be remembered that a would-be facetious barrister once remarked that prevaricators might be properly arranged in an ascending series, to wit: ordinary fibbers, liars, and experts; an arrangement which I fear meets with the approval of many members of the bench and bar to-day. The cause for such harsh classification is not so very far to seek. It is based upon ignorance on the part of the bar, and at times upon what is worse than ignorance on the side of the "expert." With the culpable acts of the pseudo scientist we cannot waste our time. That he merits prompt condemnation is axiomatic; but a word is wanted touching upon what may be termed the ignorance of the court.

"When I take my place upon the witness stand," said a prominent toxicologist once to me, "I can never predict in what shape I shall be upon leaving it," a feeling with which most of us can, I fancy, sympathize pretty keenly.

Is it that we fear exposure of the weak points in our professional armor? Do we dread to say in public, "I do not know"? Hardly that, I take it. We are now possessed of so very little of that which one day may be known that no true scientist hesitates for an instant to plead legitimate ignorance. What really troubles us upon cross examination is that the court does not speak our language, a language often quite difficult of direct translation; that it is but rarely schooled in the principles of our science; and that, in consequence, it frequently insists upon categorical answers to the most impossible kind of questions.

The hypothetical questions showered upon the expert witness are sometimes veritable curiosities, so peculiar are they in their monstrosity. Who among us but has felt that the layman, who has simply to testify to observed facts, has an easy time of it indeed, when compared with him from whom there is expected an opinion under oath?

All scientific men are willing and anxious to have their work scrutinized carefully by their peers; but to be exposed to the one-sided criticism frequently encountered at the bar is quite another matter; for it must be remembered that after the adverse counsel has opened up what appears to be a glaring inconsistency in the testimony, the redirect examination may utterly fail to repair the breach, because of a lack of familiarity with a technical subject on the part of the friendly attorney.

This leaves the witness in the unenviable position of

* Address before the American Association for the Advancement of Science, August, 1897.

disagreeing with the general drift of his own testimony, while it deprives him of suitable means of insisting upon its revision and correction.

According to the writer's view, there is but one way to escape such dilemma, and that is by direct and immediate appeal to the judge; urging that the oath taken called for a statement of the whole truth and not the misleading portion already elicited.

To illustrate how serious a matter the partial testimony of an expert witness may be, and to show also to what extent lawyers may go who look only to the winning of their causes, permit me to refer to an already reported poison case in which I was employed by the people. It may be roughly outlined as follows:

Much arsenic and a very little zinc were found in the stomach.

The body had not been embalmed, but cloths wrung out in an embalming fluid containing zinc and arsenic had been spread upon the face and chest.

Medical testimony showed that no fluid could have run down the throat. Knowing the relative proportions of zinc and arsenic in the embalming fluid, the quantity of arsenic found in the stomach was twelve times larger than it should have been to have balanced the zinc also there present, assuming them to have both come from the introduction of the said embalming fluid by cadaveric imbibition. Other circumstantial evidence was greatly against the prisoner.

At the time of my appearing for the people, on the occasion of the first trial of the case, my direct testimony brought out very strongly the fact that a fatal quantity of arsenic had been found in the stomach, but no opportunity was given me to testify to the presence of the zinc found there as well, although the fact of its existence in the body was known to the prosecution through my preliminary report. Through ignorance of the nature of such report on the part of the defense, no change was made in the character of becoming acquainted with his whole story. Do not such differences in legal opinion make it very desirable that the expert, at least in capital cases, should be the employe of the bench rather than of the bar, in order that whatever scientific investigations are made may be entirely open to public knowledge and criticism?

Although the expert should earnestly strive to have what he has to say presented in the best form, he must remember that to secure clearness, particularly before a jury, technicalities should be reduced to a minimum. To a degree they are unavoidable, but let them be as few as possible. Illustrations should be homely and apt; capable of easy grasp by the jury's minds, and if possible taken from scenes familiar to the jury in their daily lives.

It is an unfortunate fact that the expert must be prepared to encounter in the court room not only unfamiliarity with his specialty, but also deep rooted prejudices and popular notions hoary with age and not to be lightly removed from the mind by the words of a single witness. As President Jordan has well said, "There is no nonsense so unscientific that men called educated will not accept it as science;" and, let me add, they will calmly attempt to shove the burden of proof upon the scientific man who is opposed to their views. Sanitary experts, in particular, run up against all sorts of popular superstitions and are inveighed against as "professors" by those who consider themselves the "practical" workers of the time; and, let it be noted, the burden of proof is uniformly laid upon these "professors'" shoulders, while the most astounding and occult statements made by the "practical" men may be received without verification.

One source of trouble, which perhaps is peculiar to the water expert, lies in the impossibility of utilizing analytical results such as were made many years ago.

Those who are not chemists fail to grasp the fact tion carries. When the expert reaches a position of such prominence that he can state a thing to be so because he says it, irrespective of whatever may be written on the subject to the contrary, his course then is greatly simplified; but long before he attains that altitude he will have put himself upon record in many cases, and happy for him if the record so made be such as cannot be quoted to his disadvantage.

"If I had only not written my first book," is the reflection of many a distinguished author; while one of the great masters of music, referring to an opera, said: "It is one of my early crimes."

Above all things, the expert "should provide things honest in the sight of all men."

It is well for him to be deeply interested in his case, to feel in a measure as if it were his own, but it is unwise in him to become so partisan as to let his feelings affect his good judgment, and it would be indeed criminal should he permit his interest in any way to contort the facts.

Before the case is brought to a final hearing, it may be apparent that experiments before the court are possible and they may be demanded by the counsel in charge of the case. If such experiments be striking, easy of execution, and not too long, by all means make them.

Practical illustrations, particularly such as involve some fundamental principle, have great weight with the court; but these illustrations must not be such as would turn the court room into a temporary laboratory and involve the loss of much time in vexatious waitings.

Such experiments as are determined upon should be thoroughly rehearsed beforehand, no matter how simple they may be; for, of all failures, the court room experiment which declines to "go off" is perhaps the most dismal.

This brings to mind a kindred topic upon which there should be a word of caution: laboratory experiments,

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my testimony during the cross examination, and I was permitted to leave the witness stand with a portion of my story untold. No witnesses were called for the defense, and the case was given to the jury with the darkest of prospects for the prisoner.

For many reasons, unnecessary to recount here, I was distinctly of the opinion that murder had been committed, but I felt, nevertheless, that common justice demanded that the prisoner should have been entitled to whatever doubt could have been thrown upon the minds of the jury, no matter how far fetched the foundations for such doubt might have been.

The first trial resulted in a disagreement of the jury. I was pleased to learn, before the second hearing of the case began, that the defense was prepared to go into the question of the embalming fluid; for the responsibility of permitting only a part of what I knew to be drawn from me, to the entire exclusion of the remaining portion, was greater than I wished to assume. The nature of my report to the coroner having been established, and certain opinions relating thereto having been fully ventilated, the jury were possessed of "reasonable doubt" and acquitted the prisoner. What now were the duties of the expert upon the occasion of the first trial of this case and how should he have construed the meaning of his oath?

One eminent legal light, to whom the question was referred, held that the expert was distinctly the property of the side employing him, and that his duty was simply to answer truthfully the questions put to him, without attempting to enlighten the court upon facts known to him, but not brought out by the examination, no matter how vital such facts might be.

Another held that although the above course would be proper in a civil case, yet, in a matter involving life and death, the witness should insist upon the court that the examination of water may not be looked upon from the same point of view as the analysis of an iron ore. The statement that water analysis is but of recent birth, and that it is yet in its infancy, is hard for them to appreciate, holding, as they naturally do, that what was true twenty years ago must be true to-day, if science does not lie.

A pit into which many an expert witness falls is prepared for him by insidious questions leading him to venture an opinion upon matters outside of his specialty. It is a fatal error to attempt to know too much. Terse, clear answers, well within the narrow path leading to the point in question, are the only safe ones; and when the line of inquiry crosses into regions where the witness feels himself not truly an expert, his proper course is to refuse to testify outside of the boundaries of his legitimate province.

Unfortunately the expert is as often invited to take these collateral flights by the side employing him as by the opposition. Affidavits in submitted cases are commonly written by the lawyers and not by the expert, although they are, of course, based upon his reports. In the strength of his desire to win the case, the lawyer often prepares a much stronger affidavit than his witness is willing to swear to.

The writer has had no little difficulty just at this point, and has had plenty of occasion to observe the irritation displayed by counsel upon a refusal to indorse statements which have been "too much expanded."

Every expert witness, especially in his early cases, is sure to have adverse authorities quoted against him; therefore it behooves him to be so familiar with the literature of his subject as to be capable of pointing out that such and such a writer is not up to date, or that such and such a passage, if quoted in full, would not bear the adverse construction that its partial presentation which work to perfection, may utterly fail when expanded to commercial proportions, so that it is wise to bear in mind the danger of swearing too positively as to what will happen in large plants, when the opinion is based only upon what is observed to occur upon the smaller scale. Like conditions will, of course, produce like results, but it is marvelous how insidiously unlooked-for conditions will at times creep into one's calculations, and how hard it is even to recognize their presence.

When preparing his case for presentation, the expert often errs in not dwelling more largely upon certain points because he thinks them already old and well known. To him they may be old, but to the public they may be of the newest. Not only is the public unequally posted with the specialist, but what it once knew upon the subject may have been forgotten. It is well, therefore, to insert, in a special report, matters that would be properly omitted from a paper prepared for a professional audience.

Sanitary problems are of especial interest to the public, but the amount of ignorance, or rather false knowledge, displayed concerning them is surprising and often difficult to combat. The sanitarian is not unfrequently called upon suddenly to defend a position involving complex statistics; and, because the data cannot be forthwith produced, the inference is drawn that his points are really without facts to support them and that they are consequently not well taken.

Long before he gets into court, particularly if the time for preparation of the case be short, the expert may well "pray to be delivered from his friends." He may receive a peremptory order by telegraph to "determine the mineral qualities of this rock," when the telegram should have read: "Assay this ore for silver;" and later it may be a matter of surprise that a quanti-

tative knowledge of the copper present was not obtained while passing along the line for the determination of the silver; for it is not generally known that the complete analysis of anything is quite rare and correspondingly tedious and expensive.

Toxicologists who hear me may call to mind some case involving a search for the presence of an alkaloid, strychnia for example, during which search, the district attorney, in his eagerness for information, may have asked to know what the indications were as to the presence of the poison, at a time when the extraneous organic matter was not nearly removed. He may have wished no final report, but only the simple probabilities, whereon to base a possible arrest. Such requests are very common, and are akin to a demand for a proof of the pudding during the early baking, when we all know that such proof comes at a much later stage of the proceedings.

Finally, "When doctors disagree, who shall decide?" This question is often very vigorously settled by the jury, as was instanced in a recent celebrated murder trial in New York City. In that case what the experts had to say on either side was simply thrown overboard as a whole, and the finding was based upon the testimony of the remaining witnesses.

What can be said upon this question of the disagreement of expert witnesses? First, it must be noted, they are far from being the only class of people who fail to agree, and that, too, on very important subjects. Do my hearers think it would be a very difficult task to find a small army of men who would testify very variously and very positively upon questions of politics or religion? Would it be hard to find "good men and true" who would give under oath greatly differing opinions concerning the propriety of instituting free trade or establishing an inheritance tax? Experts are subject to the same errors of judgment as befall the rest of professional humanity, and, when their opinions clash, they are entitled to the same respect that we grant to the members of the bench when they hand down the decision of a divided court.

One fruitful opportunity for disagreement always arises when questions are brought into court touching upon matters newly discovered and apart from the well beaten path of common professional knowledge. Doubt is often left upon the minds of those seeking the light, even when the testimony is given by the specialist who originally developed the new point in question, for one cannot be expected to be thoroughly educated in that which he has himself but recently discovered.

Many of us have dreaded to see the "ptomaines," or putrefactive alkaloids, make their way into court with their mystifying influences upon judge and jury and their tendency to protect crime. Now that they are in, what is to be the end? Even with no "ptomaine theory" possible, the ptomaine form of argument is not unknown. The writer was once asked in an arsenic case whether he was willing to swear that at some future time an element would not be discovered giving the stated reactions now called arsenical. Such nonsense is of course instituted to impress the jury, and is suggested by similar questioning in the alkaloid cases.

A recent and somewhat amusing instance arose from an attempt to introduce the rather new conception of "degeneracy" into a murder trial. The defense sought to show that the prisoner was a "degenerate," and offered expert testimony as to the meaning of the term and as to the signs whereby such a condition was to be recognized; whereupon the prosecution called attention to the fact that the defendant's experts themselves exhibited every one of the signs in question.

Having said all that he was to say, and having stated it to the best advantage, should the expert depend upon the stenographer so recording it as to allow of its being used in future without correction? Decidedly not.

The average stenographer is unfamiliar with technical terms, especially such as are chemical, and the witness who fails to supervise the minutes may find out later that he was sworn to a most remarkable array of "facts." The writer once discovered that he had recommended, as a very efficient method of purifying a city water, the filtering of the entire supply "through a layer of black mud." Not to take your time further, let us summarize what has thus been briefly said:

The expert witness should be absolutely truthful, of course; that is assumed, but beyond that he should be clear and terse in his statements, homely and apt in his illustrations, incapable of being led beyond the field in which he is truly an expert, and as fearless of legitimate ignorance as he is fearful of illegitimate knowledge.

Mounting the witness stand with these principles as his guide, he may be assured of stepping down again at the close of his testimony with credit to himself and to the profession he has chosen.

PERPETUAL MOTION.—I.*

The search after "perpetual motion"—so called—though centuries of vain effort have brought only failure, still captivates those who believe in the possibility of such a machine, exacting time and money from its votaries. To the end that it may be seen how hopeless are all such efforts, and that inventive genius may be turned into more profitable channels, we have decided upon publishing the present series of articles.

It is not designed to make these papers a connected history of the numerous attempts which have been made at solving this problem. Our object will be principally to place before our readers some of the most plausible devices that have deceived people into waste of time and money, that others may shun these false paths; for it is noteworthy that not one of the devices which have been brought to our notice by modern inventors, in the course of our long and large practice as patent solicitors, has not had its prototype in some invention that preceded it. "There is nothing new under the sun," said Solomon the wise, and certainly so far as "perpetual motion" machines are concerned, Solomon was right.

Many people are not very clear in their ideas of what is meant by "perpetual motion," and the term itself is one of those unfortunate ones calculated to mislead those who do not use language critically.

The perpetual motion so long sought by inventors is not something that moves or will continue to move forever, or that will move till it wears out. A water wheel placed on a never failing stream is a perpetual motion, if this be the true meaning of the term. Neither is it a machine that, once set in motion by an external force, will retain its motion forever, or until it is stopped by the action of another external force, though even such a machine has never been constructed by human hands. A wheel armature suspended from a magnet having just power enough to keep it from falling, and placed in vacuo is probably the nearest approach to such a machine ever attained by mortals. The pendulum hung on knife edges in vacuo will retain its motion nearly as long. Theoretically, if we can eliminate from any moving body all resistances, it would never cease moving and would become literally a perpetual motion, though not the thing sought. The motions of the tides, the rotation of the earth, and the motions of the heavenly bodies, will continue for ages, but of these there is not one of which an astronomer would dare to predict that it will never cease.

So far as we can see, there is no single motion in nature that can be called perpetual, though change is perpetual, and motion somewhere, either of molecules or masses, must, according to the conclusions of modern science, always exist. Such can be the only conclusion drawn from the doctrine of the "conservation of force," of which the great Faraday said that it is the highest physical law of which the human mind can form any conception.

The perpetual motion of which visionaries have dreamed, and for which enthusiasts have labored, is a machine that will, under ordinary circumstances, start itself and increase its motion till it reaches a maximum, overcoming the resistances of air and friction, and possessing a surplus of motion to spare for the impulsion of other machines not self-moving. That there may be no mistake, in terms, let us adopt the name of "self-mover" for this supposed desideratum. It is not a new term, but is the only one that does not mislead thought in the consideration of the subject. Of the term "perpetual motion" Prof. Nichol, in his "Physical Sciences," says:

"If this famous appellation had simply meant perpetuity or indestructibility of force, it would have stood for an important and undeniable truth. No force is lost in the universe; we never discern the loss, but only the conversion of force, e. g., when a machine is brought to a stand through friction, all that has occurred is—the force applied to move the machine has, through the resistance we call friction, been converted into a mechanical equivalent of heat; and this heat, by communication and radiation, is in existence playing its equivalent mechanical part. But this is not the common or practical conception attached to the term perpetual motion. It has ever signified as follows: A machine whose characteristic is that the initial or primary force shall be restored or replaced by the very movement it produces. Now, setting aside the fact that, in every machine of earthly materials, part of the initial force must ever be converted into heat and dissipated through effect of friction, it is clear that, were such a machine consummated, the effect would be not motion, but equilibrium or rest. A machine is a mere medium of connection between power at one end and effect at the other; and were these two equal, the machine would simply stand still. The negation of the possibility of perpetual motion may therefore be accepted as an axiom in mechanical science. Mr. Grove has recently shown, in a most ingenious essay read before the Royal Institution of London, that important uses may be made of this axiom as an aid in scientific research. He has illustrated, by many important instances, that, considered as a test, it might enable us to discern in any experiment to what degree of approximation we have obtained, from any given natural force, the total quantity of power it is capable of affording; and that it might also serve, on the discovery of any new phenomenon, to show up to what point that phenomenon might be put in relation with phenomena formerly known."

From what we have said it will be inferred that we believe a self-moving machine to be an impossibility; but while we entertain this view, we do not forget that many able minds have held an opposite opinion, and that it has been even claimed that in two instances such machines have been actually constructed. These instances will receive notice in their proper place hereafter. We do not, then, "sit in the seat of the scornful," in regard to those who have attempted to reach the goal which has by its delusive promises led many an unfortunate inventor on to his ruin. Nor will we dogmatically assert that our opinions are infallible. All we say is, that we believe those opinions founded on sound scientific principles, and that whoever tries to produce a self-mover is wasting his time, money, and powers to no purpose.

John Wilkins, the Bishop of Chester, who died in 1672, and who, during his life, wrote upon the subject, classes the means employed to reach the desired object under these heads:

1. By Chymical Extractions.
2. By Magnetical Virtues.
3. By the Natural Affection of Gravity.

He says:

"The discovery of this hath been attempted by Chymistry. Paracelsus and his followers have bragged, that by their separations and extractions they can make a little world which shall have the same perpetual motions with this microcosm, with the representation of all meteors, thunder, snow, rain, the courses of the sea in its ebbs and flows, and the like. But these miraculous promises would require as great a faith to believe them, as a power to perform them; and tho' they often talk of such great matters,— . . . yet we can never see them confirmed by any real experiment; and then, besides, every particular author in that art hath such a distinct language of his own (all of them being so full of allegories and affected obscurities), that 'tis very hard for any one (unless he be thoroughly versed amongst them) to find out what they mean, much more to try it.

"One of these ways (as I find it set down) is this: Mix five ounces of ☿ with an equal weight of ♃; grind them together with ten ounces of sublimate; dissolve them in a cellar upon some marble for the space of four days, till they become like oil olive; distil this with fire of chaff, or driving fire, and it will sublime into a dry substance; and so, by repeating of these dissolvings and distillings, there will be at length produced divers small atoms, which, being put into a glass well luted, and kept dry, will have a perpetual motion.

"I cannot say anything from experience against this; but methinks it does not seem very probable, because things that are forced up to such a vigorousness and activity as these ingredients seem to be by their frequent sublimings and distillings, are not likely to be of any duration. The more anything is stretched beyond its usual nature, the less does it last; violence and perpetuity being no companions. And then, besides, suppose it true, yet such a motion could not well be applied to any use, which will needs take much from the delight of it."

This example is enough, we think, to satisfy our readers of the absurd character of the attempts to obtain a self-mover by "chymical extractions," and though chemistry has advanced to the front rank of sciences since that time, any attempt to get a perpetual motion through its aid would be even more absurd to-day than in Wilkins' time, since it is, in a great measure, through the aid of this science that molecular physics has advanced to the knowledge of the "conservation of force."

The second class of means, viz., by "magnetic virtues," is exemplified by a device of which we give here with an engraving (Fig. 1).

Of this, and similar attempts, our author says:

"But amongst all these kinds of inventions, that is most likely, wherein a loadstone is so disposed that it shall draw unto it on a reclined plane a bullet of steel, which steel, as it ascends near to the loadstone, may be contrived to fall down through some hole in the plane, and so to return unto the place from whence at first it began to move; and, being there, the loadstone will again attract it upwards till coming to this hole, it will fall down again; and so the motion shall be perpetual, as may be more easily conceivable by this figure:

Fig. 1.

"Suppose the loadstone to be represented at A B, which, though it have not strength enough to attract the bullet, C, directly from the ground, yet may do it by the help of the plane, E F. Now, when the bullet is come to the top of this plane, its own gravity (which is supposed to exceed the strength of the loadstone) will make it fall into that hole at E; and the force it receives in this fall will carry it with such a violence unto the other end of this arch, that it will open the passage which is there made for it; and by its return will again shut it; so that the bullet (as at the first) is in the same place whence it was attracted, and, consequently, must move perpetually."

But however this invention may seem to be of such strong probability, yet there are sundry particulars which may prove it insufficient: for

"This bullet of steel must first be touched, and have its several poles, or else there can be little or no attraction of it. Suppose C in the steel to be answerable unto A in the stone, and to B; in the attraction, C D must always be directed answerable to A B, and so the motion will be more difficult; by reason there can be no rotation or turning round of the bullet, but it must slide up with the line, C D, answerable to the axis, A B.

"In its fall from E to G, which is motus elementaris, and proceeds from its gravity, there must needs be a rotation of it; and so 'tis odds but it happens wrong in the rise, the poles in the bullet being not in the same direction to those in the magnet; and if in this reflux it should so fall out, that D should be directed toward B, there should be rather a flight than an attraction, since those two ends do repel, and not draw one another.

"If the loadstone, A B, have so much strength, that it can attract the bullet in F, when it is not turned round, but does only slide upon the plane, whereas its own gravity would rowl it downwards; then it is evident the sphere of its activity and strength would be so increased when it approaches much nearer, that it would not need the assistance of the plane, but would draw it immediately to itself without that help; and so the bullet would not fall down through the hole, but ascend to the stone, and, consequently, cease its motion; for, if the loadstone be of force enough to draw the bullet on the plane, at the distance F B, then must the strength of it be sufficient to attract it immediately unto itself when it is so much nearer as E B. And if the gravity of the bullet be supposed so much to exceed the strength of the magnet, that it cannot draw it directly when it is so near, then will it not be able to attract the bullet up the plane, when it is so much further off.

"So that none of all these magnetical experiments, which have been as yet discovered, are sufficient for the effecting of a perpetual motion, though these kind of qualities seem most conducible unto it; and perhaps, hereafter, it may be contrived from them."

From among many devices under the third class, we select the one shown in Fig. 2, whereby the desired motion is sought through the action of fluid weights:

"Where the figure, L M, at the bottom, does represent a wooden cylinder with helical cavities cut in it, which at A B is supposed to be covered over with tin plates, and three water wheels upon it, H I K; the lower cistern, which contains the water, being C D. Now, this cylinder being turned round, all the water which from the cistern ascends through it, will fall into the vessel at E, and from that vessel being conveyed upon the water wheel, H, shall consequently give a circular motion to the whole screw. Or, if this alone should be too weak for the turning of it, then the same water which falls from the wheel, H, being re-

* Reprinted from the Scientific American, 1870-71.

ceived into the other vessel, F, may from thence again descend on the wheel, I, by which means the force of it will be doubled. And if this be yet unsufficient, then may the water which falls on the second wheel, I, be received into the other vessel, G, and from thence again descend on the third wheel at K; and so for as many other wheels as the instrument is capable of. So that, besides the greater distance of these three streams from the center or axis by which they are made so much

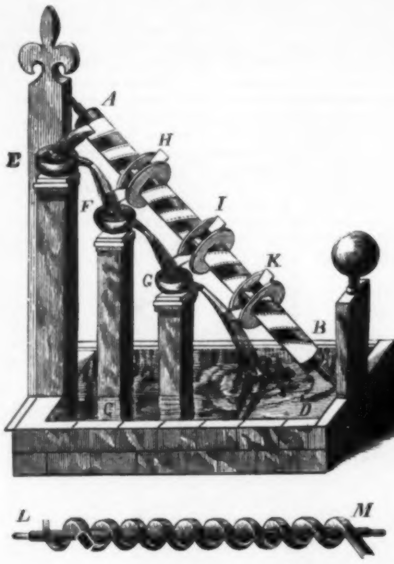


FIG. 2.

heavier, and besides that the fall of this outward water is forcible and violent, whereas the ascent of that within is natural—besides all this, there is thrice as much water to turn the screw as is carried up by it.

"But, on the other side, if all the water falling upon one wheel would be able to turn it round, then half of it would serve with two wheels, and the rest may be so disposed of in the fall as to serve unto some other useful delightful ends.

"When I first thought of this invention, I could scarce forbear, with Archimedes, to cry out eureka, eureka; it seeming so infallible a way for the effecting of a perpetual motion that nothing could be so much as probably objected against it; but, upon trial and experience, I find it altogether insufficient for any such purpose, and that for these two reasons:

"1. The water that ascends will not make any considerable stream in the fall.

"2. This stream, tho' multiplied, will not be of force enough to turn about the screw.

"1. The water ascends gently, and by intermissions; but it falls continually, and with force; each of the three vessels being supposed full at the first, that so the weight of the water in them might add the greater strength and swiftness to the streams that descend from them. Now, this swiftness of motion will cause so great a difference betwixt them that one of these little streams may spend more water in the fall than a stream six times bigger in the ascent, tho' we should suppose both of them to be continuate; how much more, then, when as the ascending water is vented by fits and intermissions, every circumvolution voiding so much as is contained in one helix; and, in this particular, one that is not versed in these kind of experiments may be easily deceived.

"But, secondly, tho' there were so great a disproportion, yet, notwithstanding, the force of these outward streams might well enough serve for the turning of the screw, if it were so that both its sides would equiponderate the water being in them (as Ubaldus hath affirmed). But now, upon farther examination, we shall find this assertion of his to be utterly against both reason and experience. And herein does consist the chief mistake of this contrivance; for the ascending side of the screw is made, by the water contained in it, so much heavier than the descending side, that these outward streams, thus applied, will not be of force enough to make them equiponderate, much less to move the whole."

In the library of the British Museum is an edition of "A very necessarie & profitable booke, concerning Nauigation, compiled in Latin by Joannes Taisnierus, a public professor in Rome, Ferraria, and other universities in Italie of the Mathematicalles, named a Treatise of Continuall Motions; translated into English by Richard Eden." It is a black letter quarto tract, printed by Richard Jugge, without date, consisting of eighty-two pages. The first part is "Of the Vertue of the Loadstone," and the second part is "Of continual motion by the said stone Magnes." It was reprinted in 1579. In his introductory remarks, he observes, in allusion to continual motion, that it is—

"The thing which to this day in manner from the beginning of the world, great philosophers with perpetual studie and great labour, have endeavoured to bring to effect, and desired end, hath neverthelesse hitherto remayned eyther unknown or hydde, not without great damage & hyndrance of most expert mathematicians. . . .

"From the begynnyng of the worlde, in manner all naturall philosophers and mathmatitians, with great expences and labour, have attempted to fynde out a continual motion or moovyng; yet unto this day have few or none atteyned to the true ende of their desyre. They have attempted to doo this with divers instrumentes & wheeles, & with quicksylver, not knowyng the vertue of this stone. Neyther can continual motion be founde by anye other meanes, than by the stone Magnes, in this maner. Make a holowe case of sylver, after the fashion of a concave glasse, outwardly laboured with curious art of gravyng, not onely for ornament, but also for lyghtnesse; the lyghter that it is, so much the more eassyer shal it be mooved, neyther must it be so pearced through, that such as are ignorant of the hyd secrete, may easyly perceyve it. . . .

"It must have on the inner syde certayn little nayles & denticles or smal teeth of iron of one equal weyght, to be fastened on the border or margent, so that the one be no further distant from the other, then is the thycknesse of a beane or chick pease. The sayd wheele also must be in all partes of equall weyght, then fasten the exiltree in the myddest, upon the whiche the wheele may turne, the exiltree remayning utterly immoveable. To the whiche exiltree agayne shal be joyned a pynne of sylver, fastened to the same, & placed betweene the two cases in the hyghest parte, whereon place the stone Magnes. Beyng thus prepared let it be fyrste

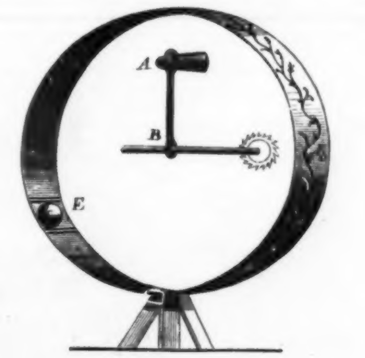


FIG. 3.

brought to a rounde fourme, then (as is sayd) let the poles be founde: then the poles untouched, the two contrarye sydes lying betweene the poles, must be fyled & pullyshed, & the stone brought in manner to the fourme of an egge, & somewhat narrower in those two sydes, lest the lower parte thereof shoulde occupie the inferior place, that it may touche the walles of the case lyke a little wheele. This done, place the stone upon the pynne, as a stone is fastened in a ryng, with such art, that the north pole may a little inclyne toward the denticles, to the ende that the vertue thereof woorke not directly his impression, but with a certayne inclination geve his influence upon the denticles of iron. Every denticle therefore shall come to the north pole, & when by force of the wheele it shal somewhat passe that pole, it shal come to the south part, whiche shal dryve it back agayne; whom then agayne the pole artike shall drawe as appeareth. And that the wheele may the sooner doo his office within the cases, inclose therein a litle calculus (that is) a litle rounde stone or pellet of copper or sylver, of suche quantitie, that it may commodiously be receyved within any of the denticles: then when the wheeles shal be raysed up, the pellet or rounde weyght shal fal on the contrary parte. And whereas the motion of the wheele downwarde to the lowest part, is perpetuall, & the fal of the pellet, opposite or contrary, ever receyved within any two of the denticles, the motion shall be perpetuall, because the weyght of the wheele & pellet ever enclyneth to the centre of the earth & lowest place. Therefore when it shal permit the denticles to rest about the stone, then shal it well serve to the purpose. The myddle places within the denticles ought so artificially to be made belowe, that they may aptly receive the fallyng pellet or plommet, as the fygure above declareth. And briefly to have wrytten thus much of continual motion may suffice.

"Description of the Engraving, Fig. 3.—A, the stone; B, the sylver pinne; E, calculus, a little rounde stone or small weyght."

Notwithstanding our author of the 15th century seems so satisfied with his invention, we find that two centuries later the world was still without the desired self-mover, for Jacob Leupold, in a work published at Leipsic in 1724, says:

"It still remains to find out this wonderful and undiscovered thing, which to the present time remains impossible both mathematically and mechanically, so far as we yet know. Great weight only increases friction, but there was a wheel or machine that did not weigh above forty pounds, and was nine feet diameter, which promised better results, yet failed like others, and so dissipated all hope of succeeding.

"Notwithstanding we hold that perpetual motion is not an impossibility, as has been shown to all the world by Councillor Orffyreus, and attested by the princely word of the Landgrave of Hesse Cassel, a prince himself well grounded in the science of mechanics, and who so minutely scrutinized and observed this wonderful motion, which was with him on trial during two months; all of which time he kept the machine in a sealed chamber.

"To all the seekers after perpetual motion the following remarks will be found most valuable:

"1. That they must endeavor to construct one of the simplest of machines; for the more material and workmanship, the less chance of durability. And if not found in such simple arrangement, it will be hid for ever.

"2. That it must be tried by experiment and not only on paper, for the friction and action can only be estimated by trial.

"3. That unless grounded in the fundamental principles of mechanics, no one should attempt the project, as he will only lose time and money. The thousands who fail of success yet learn something of mechanics, and that one pound cannot move more than one pound, but always arrives at an equilibrium."

In a work entitled "A History of the Manual Arts," we find the following:

"Archimedes, of Syracuse, the greatest mathematician and the rarest engineer that was in his time, invented a sphear and an artificial heaven, wherein he did represent the rotations and revolutions of the planets," and of which Claudian gives a poetic description—"that this machin did move of itself: it was an automaton, a self-moving device;" and further, "that these motions were driven and acted by certain spirits pent within;" also of another device of "a silver heaven sent by the Emperour Ferdinand for a present to Soliman the Grand Signior," with twelve men, and a book "that shewed the use of it, and how to order and keep it in perpetual motion." An account is next given of Cornelius van Drebble, a Dutchman, of Alcmar, engineer to King James in England:

"He presented the king with a rare instrument of perpetual motion, without the means of steel, springs, or weights; it was made in the form of a globe, in the hollow whereof were wheels of brass moving about, with two pointers on each side thereof, to proportion and show forth the times of dayes, moneths, and years, like a perpetual almanack."

The accompanying engraving, Fig. 4, is taken from a work by Robert Fludd, published in 1618.

It is a water wheel which is expected through a system of gearing to operate a chain pump, which pump should raise the water necessary to propel the wheel, and so on forever. It is probably unnecessary to inform our readers that this fallacious principle has been tried in various ways, and that there are occasionally yet to be found those so unskilled in mechanical science, and incapable of seeing the radical error of the device, as to waste their substance in a repetition of this time honored blunder. We have now in mind an instance in point, in which a man spent the accumulation of an industrious life in endeavoring through various makeshifts to get such a wheel to move, and who has brought poverty upon his declining years, through his absurd experiments. It was earnestly sought by his friends to convince him that nothing in falling could perform more work than that required to raise it to the point from which it is allowed to descend, but all such efforts proved vain, and our perpetual motion seeker would not desist till he had sunk his bottom dollar. "Perseverentia vincit omnia" was his reply to every argument and appeal, a motto which perhaps is true when applied to possibilities, and the failure of which in all the attempts to secure a self-mover only strengthens the belief in the impossibility of the thing sought.

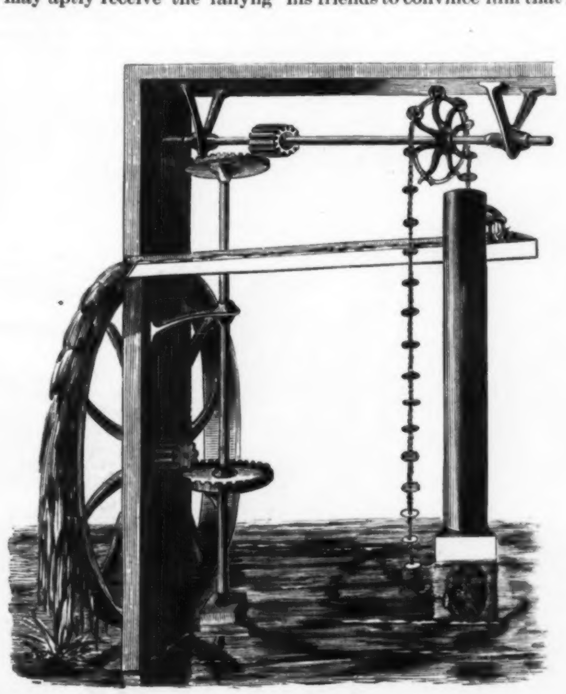


FIG. 4.

(To be continued.)

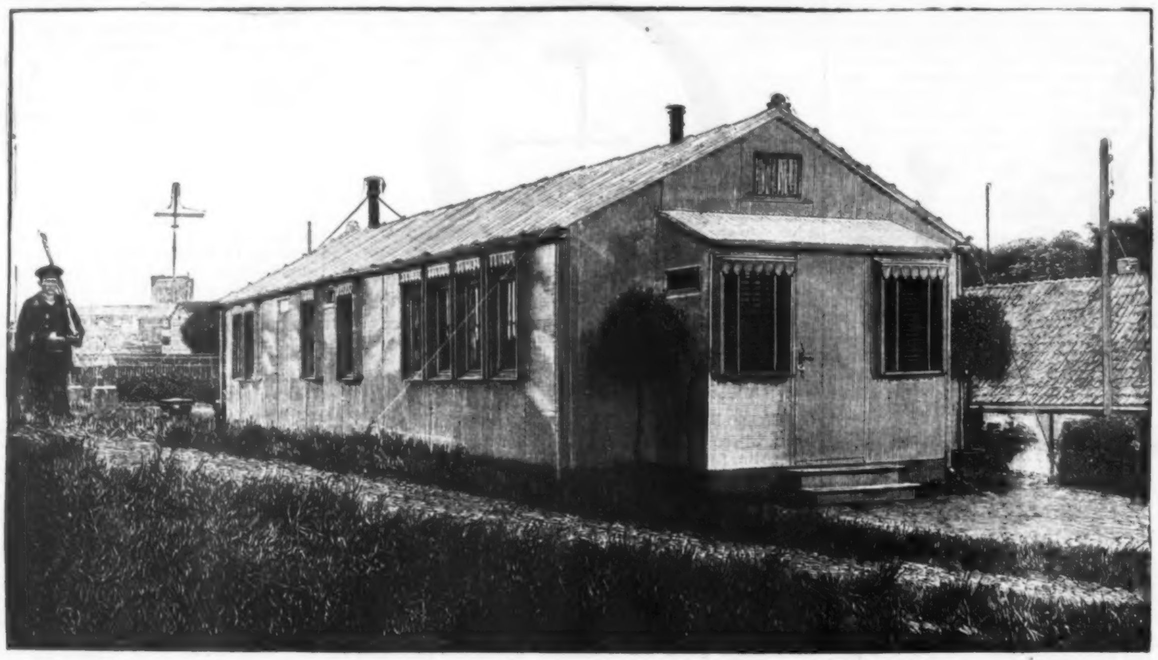
EMPEROR WILLIAM'S PAVILION ON HELIGOLAND.

For the time that the Emperor of Germany was to spend on Heligoland, at the occasion of the English Jubilee regatta, a pavilion was erected in the garden of the governor. It was constructed on the same pattern as the Döcker barracks, such as are supplied to the German, Austrian, Russian and other armies, the German navy and Red Cross societies. The usual dimensions for army use are 49×16 ft. The Emperor's barrack is some three feet longer. In its internal arrangements it differs from the others only by a slightly modified distribution of the rooms and by richer wall decorations. The whole, too, is finished in more elegant style. Besides a drawing room of 18 ft. 6 in.×16 ft. 3 in., the pavilion contains a bed room 16 ft. 3 in. square, and a bath room 16 ft. 3 in.×9 ft. 9 in., a servants' room 13 ft.×6 ft. 6 in., and a hall, 6 ft. 6 in.×3 ft. 3 in. In front of the drawing room there is an ante-chamber attached to the main part of the pavilion. Its dimensions are 9 ft. 9 in.×3 ft. 3 in. The floor is made up of 21 boxes, which serve to pack the walls, etc., for transport. When empty, they are hooked into one another by a peculiar system of connections, and they then form a strong, stable foundation for the barrack. On them the walls are erected, and they support the pavilion. All parts of the building are connected and held together by ingenious bolts.

Notwithstanding the strong wind of Heligoland, the pavilion was built up in eight hours. It stands on a small hill in the beautiful garden of the governor, with a charming view from the gable, over the sands.

The interior is simple, but elegant. The floors are covered, some with carpet, others with linoleum, and light hangings, in harmony with the furniture of the room, adorn the windows. A stove supplied by the firm Junkers und Ruh, of Karlsruhe, stands in the drawing room. The bath and stove were supplied by Joseph Junk, of Berlin, while the decorative painting was done by Lange, the hanging of the curtains by Kämpfer, both of Berlin.

For our illustration we are indebted to Illustrirte Zeitung.



EMPEROR WILLIAM'S PAVILION, HELIGOLAND.

THE PADDLE STEAMER WALTON BELLE.

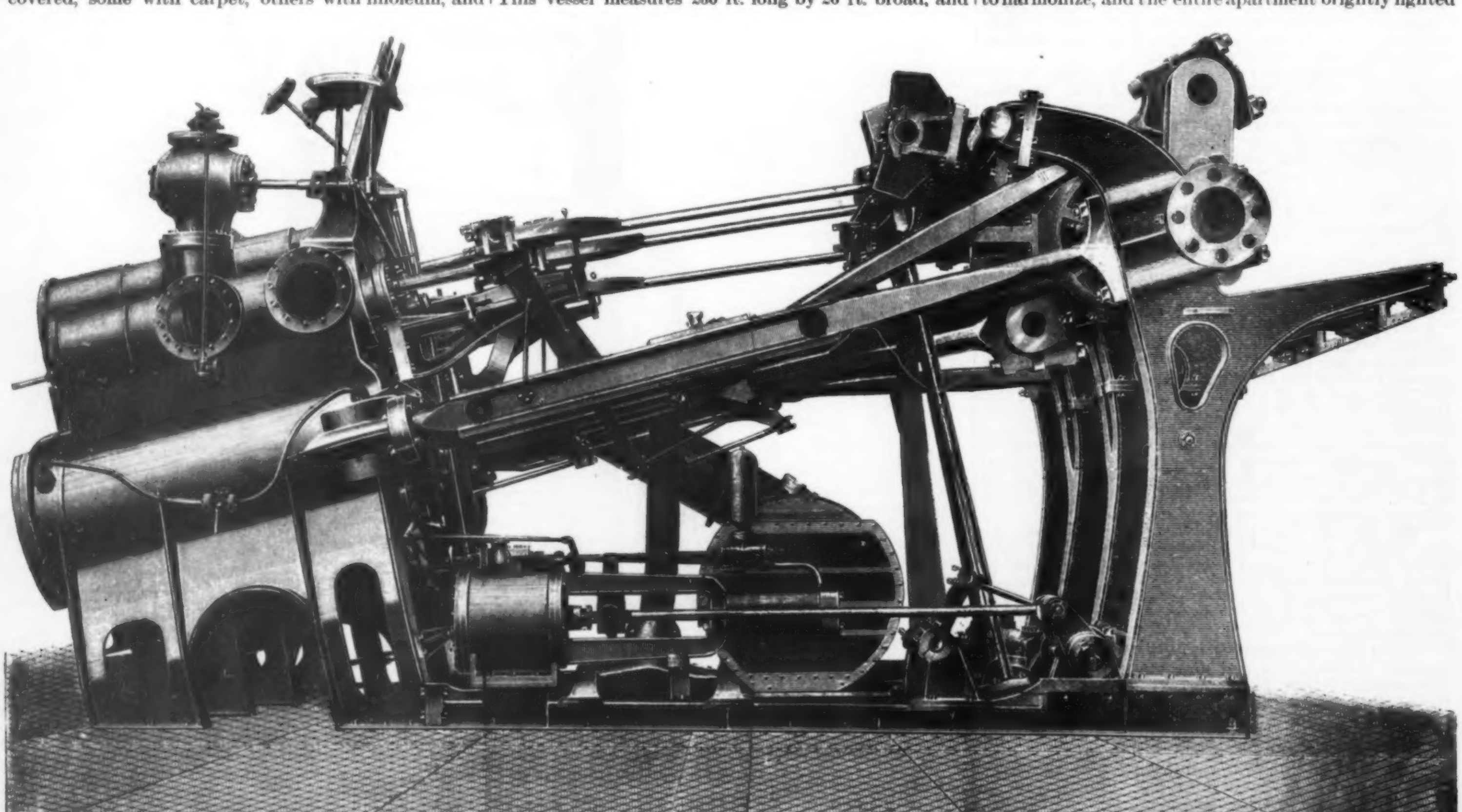
A valuable addition to the well known pleasure fleet of the Belle Steamers Company, Limited, has just been contributed from the Dumbarton yard of Messrs. William Denny & Brothers, the builders of the four other steamers owned by the company. This vessel—the Walton Belle—having first run her official trial satisfactorily on the Firth of Clyde was recently taken upon an opening trip from Fresh Wharf to the Mouse Light and back. Messrs. Denny's first contribution to the fleet of the Belle Steamers Company was the Clacton Belle of 458 tons, built in 1890. Then followed the Woolwich Belle of 298 tons, in 1891; the London Belle of 738 tons, in 1893; the Southend Belle of 570 tons, in 1896; and now the Walton Belle of 470 tons.

Colonel John M. Denny, M.P., humorously remarked on the occasion of the recent trip to the Mouse and back: "This boat is not so big as the larger ones, but she is technically and scientifically the biggest success in paddle propulsion we have ever built." In view of Messrs. Denny's performances with their Belgian, Stranraer, and Arran paddle steamers, this is saying a very great deal indeed for the efficiency of the Walton Belle. This vessel measures 230 ft. long by 26 ft. broad, and 10½ ft. moulded depth, and has a promenade deck 104 ft. long. She is primarily intended for a new service between Clacton and Yarmouth just opened by her owners in connection with their trade from London Bridge.

The steamers of the Belle Company have done a great deal toward attracting Londoners from the railway to the sea as a way of taking a summer day excursion. Already the Thames enjoys almost as great facilities in this respect as the Clyde itself, which is the birthplace of the coast excursion paddle steamer. With five millions of possible customers so close at hand, there seems no reason why this enterprise should not only prove a boon to the population, but a source of profit to the companies which have developed it. It is gratifying to learn from Mr. Peter Denny that the owners of this fleet of vessels, which have navigated the Thames and the Essex coast for six summers continuously, carrying many thousands of passengers in that time, have never lost a single life.

This success is no doubt largely, and, indeed, principally, due to the thoroughness with which the owners and their staff have conducted their operations, both in the efficiency of the vessels they have acquired and in the care with which they have been navigated. The hull of the Walton Belle is divided into nine watertight compartments, which subdivision renders her practically safe against foundering under any conceivable circumstance.

The accommodation for passengers is provided in the usual handsome and luxurious style peculiar to the fleet. The principal apartment is a "social hall," the framing of which is of polished oak and sycamore, with panels of lincrusta, the ceiling being painted and gilded to harmonize, and the entire apartment brightly lighted



TRIPLE EXPANSION ENGINES, STEAMSHIP WALTON BELLE.

by means of large windows. The sofas are upholstered in blue figured velvet, and arranged in bays, while the windows are curtained in blue and gold tapestry, the general appearance being that of a homelike drawing room.

The first class dining saloon, which is situated on the lower deck, has seating accommodation for one hundred persons at a time; the framing of this apartment is in yellow pine artistically painted, while the upholstering is in figured velvet harmonizing in color with the general decorative design of the saloon. As the total number of passengers that may be carried by the steamer is 1,500, another dining saloon is provided at the forward part of the vessel to supplement the main saloon when she is crowded. A saloon is also placed forward for the convenience of second class passengers. In addition there is a handsome boudoir for ladies, besides private cabins and private dining accommodation. The promenade deck, already alluded to, is fitted with comfortable seats, which are designed so as to serve as life rafts in an emergency. An installation of electric lighting is provided, and an elaborate system of ventilation. For handiness in navigating the upper Thames a bow rudder and suitable steering gear are fitted, while powerful steam steering gear is provided for the main rudder and controlled from the flying bridge.

The Walton Belle is propelled by a set of direct action, triple expansion, diagonal, surface condensing engines, with cylinders 20½ in., 30 in. and 43 in. and a 60 in. stroke. In order to secure both lightness and strength, cast and ingot steel, to the exclusion of cast and wrought iron, have been used wherever practicable in the machinery. The engine has three cranks, which arrangement tends to steadiness of motion. The high pressure and intermediate cylinders are fitted with piston valves and the low pressure cylinder with a double ported slide valve, all being worked by Brock's valve gear, which insures uniformity of lead at all grades of expansion. The reversing is effected by Brown's combined steam and hand gear, all the levers being brought to the starting platform.

Steam is supplied from a multitubular boiler, working at a steam pressure of 160 pounds, and constructed in accordance with the Board of Trade requirements. Forced draught arrangements are fitted in a closed stokehold, the air being supplied by a fan driven from a Bumstead engine. Denny & Company's patent spark arrester is fitted in the funnel.

The trial runs between the Cloch and Cumbrae lights on the Firth of Clyde gave a mean speed of 17·09 knots, as compared with the contract requirement of 16½ knots.

For our engraving and the foregoing particulars we are indebted to The Engineer.

LEGS OF RACING CYCLISTS.

Our illustrations show the front and rear views respectively of the legs of some well known professional cyclists. For years sporting journals have debated the question as to what is the form of musculature most desirable for a cyclist's legs, without arriving at any very definite conclusion. There is also a difference of opinion as to what part of the body has to bear the greatest strain. According to some physicians, the heart is brought into excessive action, while others hold just the contrary, that the work is rendered easier for that organ, by the task required of the other muscles, mainly those of the thigh, the cardiac spasms resulting more easily owing to the impulse given to the circulation. These advocates of cycling, moreover, state that, while other athletic exercises requiring great efforts and muscular work produce on the one hand an accumulation of carbonic acid gas, and on the other, through the frequent closing of the glottis, shortness of breath, in cycling there is no accumulation of carbon dioxide, the product of the combustion caused by the muscular work. The movement being distributed evenly over the body, the work is comparatively small, while the blood is freely supplied with oxygen by the frequent inhalations.

These details are given by Dr. Jennings. But the remarks surely do not quite apply in the case of prolonged or very rapid wheeling.

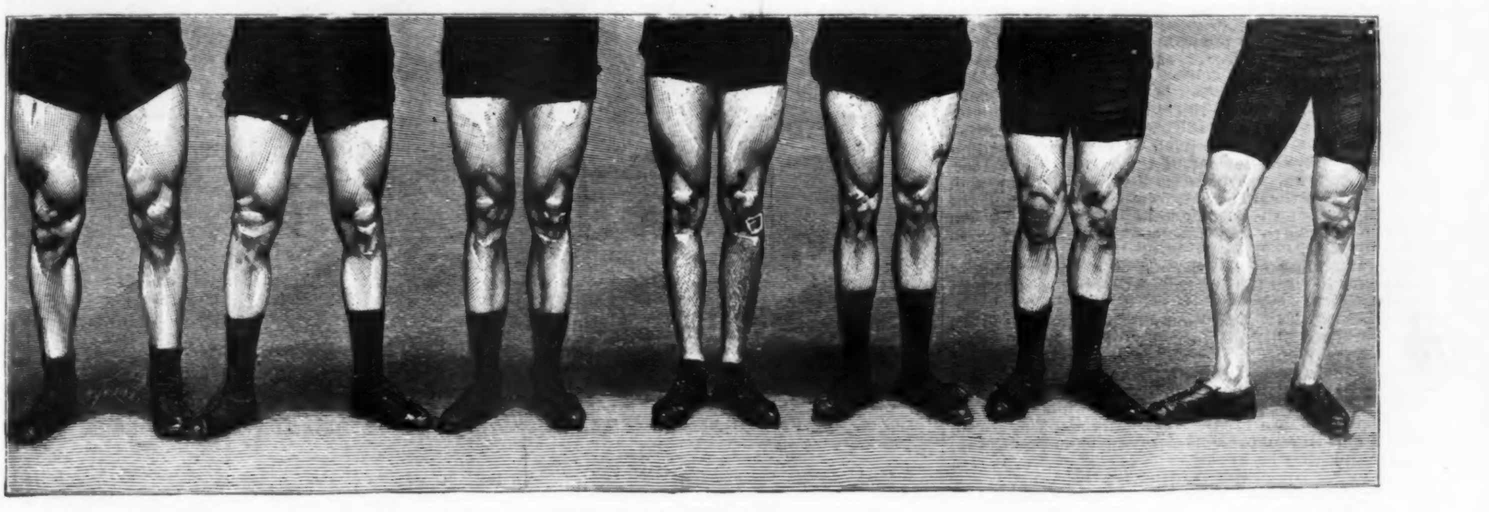
However, let us return to the subject of our illustrations. Photographs were taken of the limbs of these professionals, to establish whether they showed any analogous development. One glance at the cuts will convince the reader that such is not the case. Beside the fine anatomy of Jaap Eden, Lamberjack, for instance, shows no very remarkable build. Many noncyclists have as good thighs as Fournier, Gougoltz and Fischer. As for Huret, a stayer, strayed into the number of these sprinters, it is not his legs that distinguish him from the rest. One characteristic common to all is the abnormal development of the crural biceps and triceps, noticeable particularly in Jaap Eden. In him it becomes almost a professional deformity.

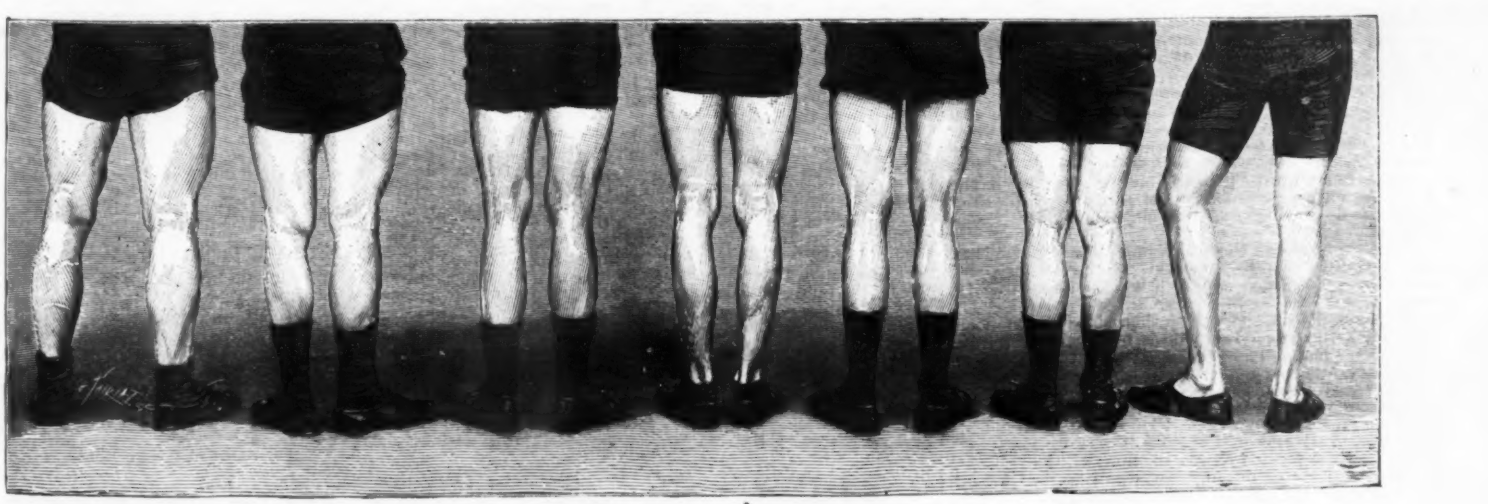
It is a pity that this reproduction in black and white cannot give fully the tint of the limbs. They are all spotted and scarred; on Lamberjack we notice a plaster at the knee. These are trophies from occasional collisions, such as occur on all racing tracks.

There seems to be no precise indication from which we can judge what is the ideal cyclist's leg. Medical men express no opinion on the question. Chappy Warburton, the famous trainer of Linton, Michael and Champion, alone has the confidence to make any assertion with regard to that question.

The professional cyclist, he says, must be an athlete. Any man who has had success in any branch of sports which requires endurance will also have triumphs on the track. Thus Eden was formerly a great skater. As for his bodily conformation, the cyclist should be built somewhat like a dog: a wide chest, in which the lungs can work freely; the lower limbs should present long, powerful levers, as in a greyhound. Zimmermann, the great American champion, had remarkably long thighs.

So much for the opinion of professionals. Our cycling readers may make their own observations from the two cuts which we borrow from L'Illustration, and form their own opinion accordingly. We will say no more, but leave them to study these assorted human limbs.





JAAP EDEN. FISCHER. PIETTE. LAMBERJACK. GOUGOLTZ. HURET. FOURNIER.

LEGS OF RACING CYCLISTS.

BRASS FACING ZINC HALF TONES AND THE METAL MOUNTING OF SUCH BLOCKS.

By E. L. Ectro.

As the unprotected surface of a zinc half tone is very liable to damage, many remedies have from time to time been suggested and tried. It has been found that a thin coating of brass has proved of great service in this direction, and an easy and simple way of depositing this alloy is here given.

Of the merits or otherwise of the hot or cold process it is not necessary to say much. Each bath has its adherents, and as both a hot and a cold bath formula is given in this paper, the worker can choose that which suits him best, as, with the exception of making up the solutions, the working is practically the same in both instances.

COLD BATH FORMULA.

Zinc carbonate	10 parts.
Copper carbonate	10 "
Soda carbonate	20 "
Soda bisulphite	20 "
Potassium cyanide	20 "
Arsenious acid (white arsenic)	½ "
Water	1,000 "

To make up the solution proceed as follows: Take twelve parts of sulphate of copper and twelve parts sulphate of zinc and dissolve them in water, then add carbonate of soda, already dissolved, to the solution. This precipitates the copper and zinc in the form of carbonates, a greenish colored powder. Allow the precipitate to settle, and pour off the supernatant liquor. Wash the precipitate, and then mix it with the carbonate and bisulphite of soda in 900 parts water. Next dissolve the cyanide and arsenic in the remaining 100 parts water and pour this into the first solution. The bath is now ready for use.

HOT BATH FORMULA.

Copper acetate	14 parts.
Zinc chloride	14 "
Potassium cyanide	30 "
Soda bisulphite	28 "
Ammonia	16 "
Water	1,000 "

Dissolve the cyanide and bisulphite in 800 parts water and add to it the other ingredients dissolved in the remaining 200 parts water. This solution is used at a temperature of about 120 deg. Fah. The vessel for containing this solution may be of iron lined with brass, and the temperature maintained by hot water, gas, fire, or steam. The cold bath can be used in an ordinary earthenware vessel, or, if the work runs large, a wooden tank lined with guttapercha will answer admirably.

The anodes should be of good stout brass. They should occasionally be removed from the solution to be cleaned, and the connections generally seen to. Care should also be taken to prevent any of the solution getting upon the hands or clothes; if such should happen, it should be immediately washed off with water.

A pair of Bunsen cells in series will be required to

deposit the metal. The cells and the method of connecting them were fully described in the issue for October, 1896, but for those readers who have mislaid that number a few brief notes are here given. The Bunsen cell consists of an outer earthenware jar containing a 10 per cent. solution of sulphuric acid. Into this a zinc cylinder amalgamated with mercury is placed. A porous pot with a block of carbon in it is filled with pure commercial nitric acid, and then placed within the cylinder of zinc, and the battery is complete.—The Process Photogram.

RAPID PROCESSES OF UNLOADING ARTILLERY MATERIAL FROM CARS.

The ordnance department is just now studying some rapid processes of unloading a battery from a train upon an open track and with its own resources. It is possible that, during the course of a war, a battery of artillery may have to be taken off a train in the open country without the aid of any of the arrangements and accessories that are found at stations for assisting in such an operation. The destruction of a track, the occupation of a station by the enemy and an unexpected attack are so many circumstances under which the artillery would have to be unloaded from the train under such conditions; so, in recent times, much attention has been paid to this question. Several processes have been studied and put to the test in France as well as in other countries. The one that appears destined to be adopted by us is that proposed by Capt. Barthelemy.

The photographs herewith reproduced represent different phases of the unloading of a battery by this method. These photographs were taken during the course of experiments made at Fontainebleau by one of the flying batteries of the seventh division of cavalry.

Capt. Barthelemy's system is based upon the following principles: (1) The utilization of the hind ladder of the forage wagon or of the artillery wagon separated from its forecarriage as an inclined plane for unloading the horses; (2) the descent of the fore and hind carriages of each wagon separately by manual labor, and, when either of them is about to touch the ground, the receiving of its hubs in some kind of support that will allow the wheels to come into contact with the earth without shock.

The unloading of the wagons of a battery will, of course, begin with the one that is to serve as a descent for the horses.

The best of the vehicles to use for this purpose is the forage wagon, which, on account of its length, gives a very gentle slope.

The artillery wagon, which gives a steeper slope, is used only in case of the absence of the forage wagon. After the wagon that is to be used as an inclined plane has been taken off the car, its fore carriage is removed, and there is thus obtained a very convenient gangway, so to speak, that just reaches the level of the floor of the wagons. Upon the floor of the wagon there is spread straw and sand, in order to render its surface less slippery.

Fig. 1 represents an unloading of horses effected by means of a battery wagon. The party that made the experiment during which our photographs were taken had no forage wagon at its disposal.

As the hind carriage of an artillery wagon is connected with the fore carriage by means of a short pole, it is the latter that rests upon the earth when the two parts are detached. The men seen at the two sides of the wagon are there to prevent any motion during the descent of the horses and to keep its upper part in close contact with the floor of the car. Further to the left is seen a man with a shovel ready to throw sand upon the floor as soon as the horse has been disembarked.

Fig. 3 represents the unloading of a fore carriage. By means of ropes possessed by the battery, the wheels have been tied, so that it will be impossible for them to revolve.

Two men placed upon the other side of the truck hold back the descending wheels by means of a rope. This rope makes one revolution around the axle of the truck, and this gives the two men considerable of a purchase. Ten other men cause the wagon to advance while holding it.

The accessory supports mentioned above have been prepared in advance and are as follows: With a forage rope there is formed a sort of sling which is placed upon the point of one of the large pickets that are carried under the artillery wagons and that are used for attaching horses to by means of ropes during a bivouac.

As soon as the axle of the fore or hind carriage that is descending reaches a distance from the earth a little greater than the height of the picket supports, one of the latter is fixed by its sling to each axle. The axle continuing to descend, the supports touch the earth. Then, instead of continuing to descend vertically, it pivots around the two points of the supports that rest upon the ground, and the tires of the wheels touch the latter without any shock.

The descent of the hind carriage of a wagon is effected in the same manner, with the difference that, as soon as it is possible, it is connected with the fore carriage that has already been unloaded.

Fig. 4 shows the descent of a hind carriage. The picket supports are here already fixed to the hubs. A gunner standing on each side holds each of the supports exactly vertical, in order that no sliding may occur when the carriage pivots around the bearing point of the supports.

All the wagons of the battery except the ammunition ones are unloaded as we have just explained. As the fore and hind carriages of the ammunition wagons cannot be separated, the latter have to be unloaded in their entirety.

In order to perform this operation everything is taken out of the wagon, and then its fore carriage is made to pass over the edge of the truck, while a sufficient number of men to balance it get on behind, so as to allow the front wheels to touch the ground without shock. The descent is effected entirely by manual power. Fig. 2 clearly shows the mechanism of this operation.

The unloading whose phases are here reproduced, and which included that of eighteen wagons and two hundred horses, took about two hours.—La Nature.

WIND PRESSURES ON HIGH BUILDINGS.*

We have been particularly requested to lay before our readers an abstract of the long, but very valuable, paper on wind pressure prepared by Mr. Julius Baier, Assoc. Mem. A. S. C. E., but it has seemed best to us to print the following copious extracts from his paper rather than a briefer abstract:

The storm of May 27, 1896, entered St. Louis from the west, progressed eastwardly through the city at some distance south of the central business section, crossed the Mississippi River and continued in a northeasterly direction through East St. Louis. . . .

The anemometer record shows the passage of 13 miles of wind in about 12 minutes; of this, a little over 6½ miles passed in five minutes, a rate of about 80 miles an hour observed, giving, when properly corrected, an actual velocity of about 62 miles per hour. The general direction was toward the south, into the storm center. . . .

A general inspection of the buildings brings out the following average characteristic features. The extreme force of the wind was generally confined to upper stories and roofs. The intensity of this force must have been extremely variable, not only as exerted on adjacent properties, but on a single building. There was very general evidence of the destructive force being exerted from the inside.

The total number of buildings destroyed or seriously damaged by the storm in the city of St. Louis, as shown by the records in the assessors' office, is 7,263. Of these, 321 were totally wrecked. The number of houses slightly damaged that can be repaired at an average cost of $75 is 1,249, making a total of 8,515. . . .

The general maximum destruction covers an area from 4,000 feet to 6,000 feet wide and nearly three miles long, lying immediately south of the central part of the city in St. Louis and extending across the river into East St. Louis. . . .

Throughout the path of the storm the buildings and wreckage show evidence of extreme and sudden variations in the intensity of the wind pressure. A striking example of this is a little pavilion left standing in Lafayette Park on a slight elevation above the general level, at a point where the broken and uprooted trees show the full force of the storm. A straw thatched roof held in a light wire netting and perched on six uprights planted in the earth, and stiffened by a few rustic braces, would seem a most inviting mark for the wind, but except for some damage due to the falling limbs of adjacent trees, it stands uninjured. . . .

Any formula expressing the relation between the pressure and velocity of the wind must be based on the assumption that the air flows in a uniform current. All experiments in the open air show that the actual conditions are far different, and the great diversity in the observed results is due largely to the continued and rapid fluctuations in the velocity of the winds. . . .

As a result of these observations Professor Langley reaches the conclusion that "the wind is not even an approximately uniform moving mass of air, but consists of a succession of very brief pulsations of varying amplitude, and that, relatively to the mean movement of the wind, these are of varying directions."

Regarding the direct effect of wind pressure on buildings, some suggestive results were obtained by Professor Kernot* with an apparatus devised to determine the relative pressures of the wind on flat plates, cubes, cylinders and other forms similar to those employed in ordinary construction. A steady jet of air 10 by 12 inches in cross section was directed against small models supported on a very delicately arranged carriage running on an accurately leveled surface plate, the force exerted being measured by a delicate spring balance. From a large number of experiments made with this apparatus he found that the pressure on sloping roofs agreed with the results of theory only when the air could blow freely underneath. With the model of a roof placed on a wall, as in an ordinary building, the air was deflected upward and greatly reduced the pressure on the roof; the effect was more marked when a parapet was used. In the case of a roof of 30° pitch, with a parapet 0·16 the height of the roof, the pressure was actually reversed, the roof having a slight tendency to lift. Experiments were tried as to the effect of the wind blowing in at the open end of a building having the sides and other end completely closed, and it was found that there was an internal pressure, tending to lift the roof and force out the sides,

* Extracts from a paper by Julius Baier, Assoc. M. Am. Soc. C. E., read before the American Society of Civil Engineers, and published in the Journal of that Society.

* Engineering Record, February 10, 1894.

Fig. 1.—ARRANGEMENTS EMPLOYED FOR DISEMBARKING HORSES.

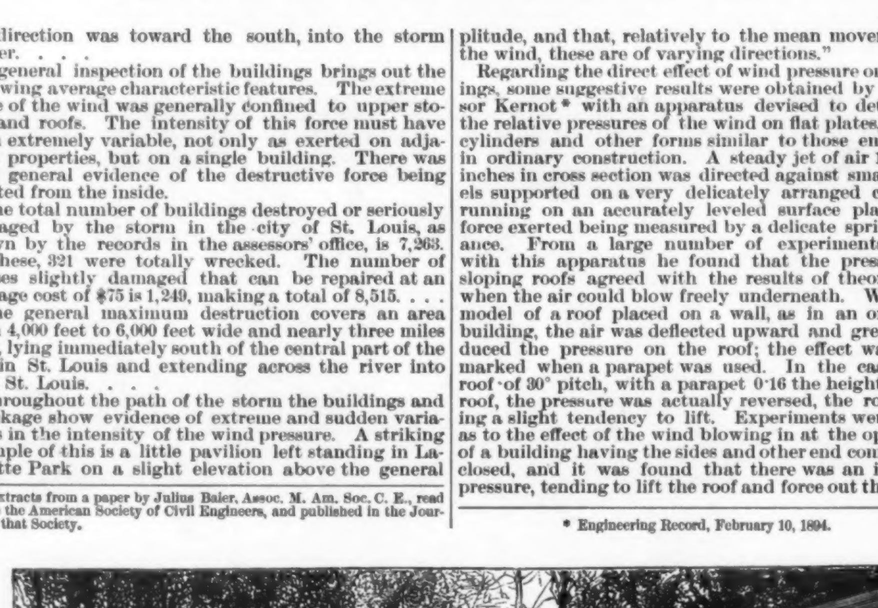


Fig. 2.—METHOD OF LETTING DOWN AN AMMUNITION WAGON.

which was equal to the pressure of the wind on the exposed end. When a plane surface parallel to the wind was brought nearly into contact with the cylinder, the pressure on the latter was increased nearly 20 per cent. owing to the lateral escape of the air around the cylinder being checked, showing that a tower or chimney will be subjected to a much greater pressure if there is a building nearly touching it on one side. The variations of pressure caused by the proximity of other surfaces were very marked; each surface appeared to affect the pressure on the other surfaces to a distance in front equal to its own breadth, and in the rear equal to several times this distance. Behind flat surfaces eddies were found to exist which caused other surfaces placed behind them to be urged forward with considerable force.

The existence of a suction on the leeward side of surfaces or bodies exposed to the wind has been generally

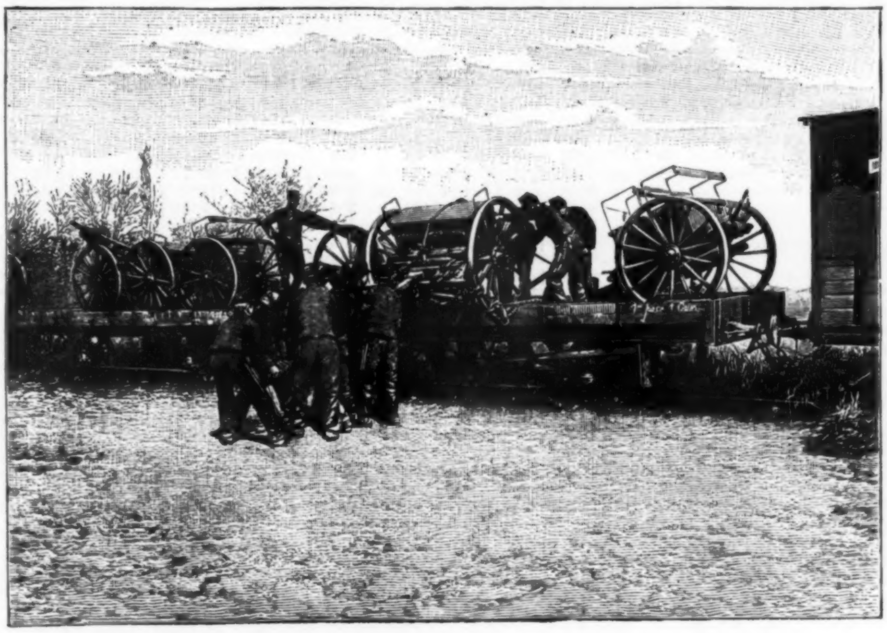


Fig. 3.—REMOVAL OF A FORE CARRIAGE FROM A PLATFORM CAR.

recognized, but the experiments of Mr. Irminger,* a Danish engineer, made to determine the amount of such suctions, shows it to be present to an unexpected extent. . . .

The most interesting result was that found for a roof sloping at an angle of 45°. The pressure on the windward side was a maximum at the eaves, and became zero near the top, changing to a suction at the ridge. The effect on the leeward side was a uniform suction. Taking the normal pressure on a plane of the same dimensions as equal to p, the proportional effect on the windward side was found to be a pressure of 0·11 p, and on the leeward side a suction of 0·36 p. The resultant effect on the total roof was a force 3½ times as large as the pressure on the windward side alone, and was inclined upward, exerting a strong lifting action. In another experiment made with the model of a building covered by a dome, the resultant of the pressure and suction upon the dome was found to act vertically upward.

The results of these experiments show that the wind acts in a direction quite different from that generally assumed and usually provided for in the designing of bridges, roofs and buildings. The evidences at St. Louis confirm this conclusion. . . .

Much of the destruction in St. Louis was undoubtedly caused by an intensity of wind pressure that it would be neither possible nor expedient to provide against in ordinary structures, but much of it was also due to weak construction. A general observance of the ordinary requirements for good building work would largely decrease the damage due to such storms. The great amount of explosive action was largely due to the comparative weakness of ordinary walls against pressure exerted from the inside of buildings. A more efficient anchorage of the walls might limit this explosive action to the windows. In numerous instances the windows were blown in on the windward side, while the entire wall was blown out on the leeward side. Brick walls are materially stronger if well bonded with the vertical joints filled with mortar, and a wall laid in cement will undoubtedly withstand a greater lateral force than one laid in lime mortar. It is worth noting that the walls of the buildings of the Union Depot Railway plant left standing were laid in cement, while the older buildings, which were entirely wrecked, had had walls laid with lime mortar. The great damage done to the churches calls attention to the great exposure of the steep and lofty roofs supported on high and comparatively thin and unbraced walls. Heavier buttresses or independent steel column supports, with bracing for the roof trusses, would materially increase the safety of such structures. In general, the buildings with large areas of unbraced walls have suffered most. . . .

The periodic prevalence of these storms, emphasized by the recent calamity in St. Louis, by the destruction in Louisville in 1890, and by a similar storm in Little Rock in 1894, and in Kansas City in 1886, gives a somewhat broader public interest to this question, and appears to call for its serious consideration. The evidence of the work of the wind in St. Louis suggests as an immediate answer to the question that it will depend largely upon the nature of the metal framework in the building. . . .

The metal framework of a building is somewhat generally called the "skeleton" and sometimes "cage." If both of these terms are to be retained in this special sense, a convenient distinction can be made by some restriction in their use suggested by the words themselves.

Skeleton is a term clearly descriptive of that type of construction to which it was first applied, a simple framework of columns and beams whose efficiency is dependent largely on the existence of exterior walls and partitions which brace the building, and hold the framework in position, just as the utility of the human skeleton is dependent upon the covering of sinews and muscles that hold the component parts together. On the other hand, the light framework of an ordinary wire cage bound into one compact unit is suggestive of an inherent strength and elastic resistance that renders any covering an incident rather than a necessity. Cage is a term peculiarly descriptive of that type of construction represented by the most advanced and approved practice, a framework of columns and beams, spliced at the joints, riveted at the connections, stiffened by an efficient bracing of rods, portals and gussets that make it independently safe against any external force, leaving the thin and light exterior walls with no duty except that of providing protection and ornamentation for the building.

The effect of an extreme wind pressure on a high office building with curtain walls must depend largely on the extent to which the frame of that building partakes of the nature of the skeleton type or the cage type of construction.

The possible work of destruction of a tornado may appear more clearly if, as Ferrel suggests, the column of rapidly revolving air is likened to a tall flue, with heated and rarefied air in its interior. If the access of air is cut off from the lower central part by the shell of gyrating air extending down to the surface, the lateral currents and ascending currents in the interior will be of no violence, but with a somewhat free access of air below into the rarefied interior, on account of a decrease by friction of the gyratory velocity near the surface, the inrush of lateral air currents becomes extremely violent and the velocity of the uprush of air in the interior becomes enormous. In the former case, the destruction is mainly due to the excessively high gyratory velocities; the destruction is complete, but the path narrow. It is the condition that may prevail in open country with but few objects to destroy the energy of the tornado. In the latter case the destruction is largely due to the violent lateral inrushing currents. The path is wider, and the force not so extreme. It is the condition which must prevail in any compactly built city, owing to the great friction of the air arising from the irregularities due to the many buildings.

The first high isolated building encountered will feel the full force of the gyratory velocity, but the resistance of the building destroys this velocity, and the work of destruction wrought on that building must represent an equivalent diminution of energy in the lower section of the tornado, which can only be renewed by its further unobstructed progress during such appreciable time as is necessary to restore the gyratory velocity. A succession of high buildings will prevent such recovery of velocity.

The destructive power of a tornado on massive building work due to these excessively high velocities is therefore soon exhausted, but the wind pressures due to the violent currents rushing in from all sides are only intensified thereby.

If a tornado storm with a well developed whirl should pass through the section of any city containing very high buildings, the general level of the top of the lower buildings becomes equivalent to the ground surface, and it seems fair to assume as the result the same general action that has been found near the surface, modified or intensified in its irregularity according to the degree of uniformity in the general height of the majority of the buildings. There may be the extreme pressures due to the gyratory velocity of the tornado proper exerted over a limited area and for a very limited time. There will be a far wider zone of lateral inrushing winds at high velocities lasting throughout the progress of the tornado and attended by the additional complications that may arise due to the concentration of air currents in the deep valleys formed by the streets between the buildings. The probable result would be an extremely variable and intense action of the wind about the tops of the lower buildings, the same action concentrated locally at about that level on the higher buildings, accompanied with a general severe pressure over the entire exposed area of the latter, this latter pressure probably being a maximum near the top or at least some distance above the general level where the friction is not so great.

A characteristic feature of the St. Louis tornado, and one which, judging from records and published views, is also common to other tornadoes and violent hurricanes, is the general destruction of the ordinary brick and stone walls. Regardless of the sequence in which they may explode outward or are blown inward, and of a possible difference of opinion as to whether the explosion is due to a plenum, a vacuum or to a suction, the essential fact remains that the walls do very generally fall.

Assuming a similar action of the wind, the buildings of an average height will probably have the walls at the top or exposed corners destroyed, or, if particularly weak, may be shaken down. The buildings above the average height would be very liable to have part of the walls at any level blown in or taken out. An office building with the curtain walls of one or more stories removed would support the remaining enveloped superstructure precisely in the manner of the grain elevator before it was struck by the storm.

If now the building is of the pure skeleton type, it will have only the elements of stability that existed in the case of the elevator—its weight—above the floor in question, and possibly some additional bracing of a more or less uncertain value, and under the action of even such pressure as may exist at some distance from the vortex of the tornado, it will fail, just as the elevator failed; it will topple over and fall to one side or toward one corner on the floor below. Instead, however, of landing on a massive stone foundation, the thousands of tons of weight of the three, four or six stories, as the case may be, of the upper section of the building will fall with a crushing force, concentrated on the leeward side, on the section below. The heavy oak girders under the leeward edge of the elevator were mashed into a bundle of splinters, while the windward edge was held some distance above the foundation. As the striking force of a freely falling body is equal to the product of its weight multiplied by the distance through which it falls—about 12 feet in the case of an office building falling one story—the resulting pressure on some of the columns may easily be ten to twenty times the load they were designed to carry and several

* American Architect, September 14, 1896.

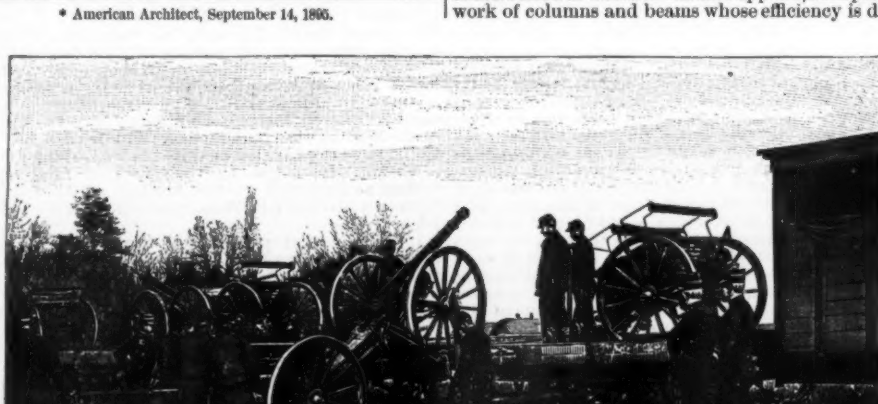


Fig. 4.—REMOVAL OF A HIND CARRIAGE FROM A PLATFORM CAR.

times their ultimate strength; the result must be a collapse of part or all of the lower section, with a possible toppling over of the upper section to one side into the street or onto a lower adjacent building.

If the building is of the cage type, it will stand safely under a wind pressure that will destroy the skeleton building. While the failure of the walls at any story may reduce the rigidity somewhat, it cannot affect the strength of a framework designed without placing any dependence on the covering. Such a framework will readily carry the lateral stresses from the upper section to the section below.

If the pressure should reach a destructive intensity, the exact line of yielding of a cage frame is not so clearly defined. The tendency to lateral displacement will be a maximum at some one story, depending on the distribution and cumulative effect of the wind pressure, aided possibly by the weakening due to localized failure of walls or partitions. As the frame is of a gradually varying strength from the top down, the distortion can hardly be confined to one level, but would probably involve the members of the adjacent stories, the effect being a general racking or leaning of the building. With strains near the ultimate strength, the failure at some point may concentrate a distortion at that level, and the upper section of the building may be pushed to one side and ultimately settle down on the floor below.

The essential difference lies in the fact that a wind of sufficient force and duration to push the upper section of a building to one side a distance about equal to the width of a column may cause total destruction in a skeleton building, while a cage under the same circumstances may suffer only a local damage that can possibly be repaired at a comparatively small cost. In a skeleton building, the instant the columns are pushed beyond the critical or balancing point, the weight is reversed in its action from an element of safety to an almost unresisted element of destruction. With a cage type of construction the weight of the building after some displacement has taken place also acts with the wind as a destructive agent, but not unresisted. The work that must be done in the necessary bending, twisting, and general distortion and breaking of the metal in the columns and beams must largely absorb the energy of the falling mass and have the effect of letting it settle down on springs. The local peculiarities of the building, the unequal distribution of the wind pressure, and the changing direction of the wind, make it more than probable that such failure will not be symmetrical, but will have a torsional effect on the upper section of the building.

However difficult it is to foresee the many possibilities, it is safe to assume that in one way or another the framework will hang together sufficiently to prevent any considerable part of the building from falling down bodily onto streets or buildings below. Even under the most extreme conditions it is difficult to conceive how such a building, or a large part of it, can entirely collapse. The general destruction of windows and walls will greatly relieve the wind pressure; the frame, partly bent, twisted and distorted, must still hold together. The chances are that most of the occupants will escape alive and many uninjured. The most striking feature of the St. Louis tornado is the countless number of hairbreadth escapes and the very small number of people killed inside of houses unless by the entire collapse of the structures; incredible as it may seem, under such extreme conditions, the fatalities attending only local failure of a building are comparatively few.

The effect of a destructive wind pressure on any high building with curtain walls may be assumed to approach that outlined above in proportion as its framework partakes of the nature of a skeleton or cage type of construction, using these terms in the restricted sense indicated in this paper.

The destructive effect of the total collapse of buildings has been too frequently noted to require further mention. The method of failure of the grain elevator, taken in connection with the view of the wreck of the skeleton framework, indicates what might happen to a high building of the pure skeleton type if brought to the point of failure. The assumed action of the cage type of building is dependent on an efficiency in general design, and particularly in the detailing of connections, which can be readily attained if the necessity for it is recognized. In the absence of any definite tests of full sized typical details used in the structural work of buildings, the action of the metal under extreme distortion must be estimated from the results shown by sample specimens, verified by occasional opportunities to notice its behavior under accidental tests of great severity that may be caused by collisions or derailments on or near bridges and viaducts. The riveted joints, mentioned earlier in the paper, show what may be expected in details involving similar principles of design.

The possibility of a high office building being actually subjected to a destructive wind pressure has often been considered, largely in the light of a theory. The St. Louis tornado passed within less than a mile of the office buildings in that city. Fortunately it made no test of the buildings, but it has left some definite evidence of the possible force of the wind and of the action of this force on the materials of construction. While it raises anew the question as to the amount of wind force which should be provided for in designing high buildings, it raises with more emphasis the question as to the method of providing for this force after its amount has been assumed. Any dependence placed on curtain walls and partitions for lateral strength is open to very grave question. The rigidity imparted to a building by the simultaneous action of the total mass of material under ordinary conditions is no indication of the ultimate strength that may be developed at a critical moment, and the very general failure of the walls under extreme wind pressure further destroys any certainty of such assistance as might be otherwise relied upon. The elements of safety against wind force, exclusive of the strength that may come from the walls and partitions where they exist, are the stability due to weight alone, stability due to the strength and stiffness of the frame, and, when the force is a sudden one, the inertia of the mass resisting motion.

It may be of interest to estimate just how sudden and how short lived the force must be to justify placing any dependence on the inertia of the structure for safety. The force required to set in motion and move over a given distance any mass, otherwise balanced, is capable of exact computation if the time allowed for such motion is known. The equation is derived from the law for falling bodies and is $F = \frac{2\,w\,d}{g\,t^2}$, where F is the total force, w the weight moved in pounds, d the distance moved over in feet, t the time in seconds, and g is 32·2.

The following table, computed from this formula, gives the force required to overcome the inertia of a ton of 2,000 pounds and move it varying distances in times varying from one second to thirty seconds.

FORCE PER TON REQUIRED TO OVERCOME THE INERTIA OF AND MOVE ANY GIVEN MASS.

Time in Seconds.	Distance Moved.									
	1 in.	3 in.	6 in.	1 ft.	2 ft.	4 ft.	6 ft.	8 ft.	10 ft.	16·1 ft.
1	10·3	31	62	124·22	248	497	745	994	1,242	2,000
2	2·6	7·7	15·5	31	62	124	186	248	310	500
3	1·15	3·4	6·9	13·8	27	55	83	110	138	222
4	0·64	1·94	3·9	7·7	15·5	31	46	62	77	125
5	0·41	1·24	2·4	4·9	9·9	19·8	30	40	49	80
6	0·28	0·86	1·72	3·4	6·9	13·8	20·7	28	34·5	55
8	0·16	0·48	0·97	1·94	3·8	7·7	11·6	15·5	19·4	31
10	0·10	0·31	0·62	1·24	2·4	4·9	7·4	9·9	12·4	20
15	0·046	0·14	0·27	0·55	1·10	2·21	3·3	4·4	5·5	8·9
20	0·026	0·078	0·155	0·31	0·62	1·24	1·86	2·5	3·11	5·0
30	0·012	0·035	0 069	0·138	0·28	0·55	0·83	1·10	1·38	2·22

Assuming, as an illustration, the weight of a ton suspended as a pendulum by a very long cord; then to swing it one foot in one second will require a force of 124·2 pounds, while the mere pressure of 1¼ pounds will accomplish the same result if the time allowed is 10 seconds, or about the average duration of a gust of wind in Prof. Langley's experiments. Applying the figures in the table to the case of a narrow building, say 32 feet wide, and assuming the upper section 100 feet high by 100 feet long, having thus an exposed area of 10,000 square feet to weigh 5,000 tons, then the force necessary simply to overcome the inertia and move this part of the building the respective distances of 1 inch, or 1 foot, or 16 feet, in various intervals of time, is equivalent to a pressure per square foot of the exposed areas as follows:

t.	d = 1 in.	d = 1 ft.	d = 16 ft.
	Lb.	Lb. per sq. ft.	Lb. per sq. ft.
1 second	5·2	62·1	1,000
2 "	1·3	15·4	250
3 "	0·5	6·9	111
5 "	0·2	2·5	40
10 "	0·05	0·6	10
15 "	0·02	0·3	4·4

These figures will readily indicate how great a resistance the inertia of a building may offer against the motion necessary to overturn it under the action of a brief gust of wind, and how comparatively little this resistance becomes as against only such motion as is necessary to push it over on its supports. To overturn the building in ten seconds, a pressure of 10 pounds per square foot is necessary to give it the necessary motion, in addition to the force required to overcome its stability. The resistance of inertia for a movement of one foot against a gust five seconds in duration will be 2·5 pounds per square foot, and for ten seconds it will be only 0·6 pound per square foot. For shorter periods the value of inertia becomes very high, but may, on the other hand, be entirely overbalanced by the cumulative effect of the vibrations of the building acting in rhythm with the pulsations of the wind: Experiments on Chicago buildings under heavy winds show the time of a complete vibration to be about two seconds. The resistance of inertia against the destructive effect of brief but intense pressure, such as the gyratory velocities in the vortex of a tornado, is fortunately very great.

Stability due to weight alone is proportional to that weight and to the breadth of base of the support. Its value as an element of safety is a most definite one and may be sufficient. Considered with reference to overturning, a large elevator or building may be safe beyond question, yet with reference to its column supports the same structure may be in comparatively unstable equilibrium, as a relatively small movement of the center of gravity will throw it out of balance. The total force required to overturn a building of a given weight increases directly with the breadth of that building, but the total force required to push it over on its supporting columns is a constant, depending solely upon the height and breadth of base of those columns, and is independent of the dimensions of the building, of the number of supporting columns, or the material they are made of. Any structural member that is used simply as a prop or support can have only such value as is incident to that use, whether it is made of wood, of stone, of cast iron or of steel.

The elements of strength and safety inherent in a well designed cage built of the proper material, with all its members thoroughly riveted together, are present in that frame in greater or less degree, until it is torn or cut apart, piece by piece. A steel frame built to be safe for a wind pressure of 30 pounds per square foot, proportioned by unit strains of one-half the elastic limit, would probably withstand a pressure from 40 to 80 pounds per square foot before the frame yields. This range depends largely on the care with which the connections have been detailed, the extent to which possible unequal settlement of the foundations has already overstrained the frame, and on the reduction of the effective surface exposed to the wind by the destruction of the walls in the panels between the framework, leaving part of the wind to blow through unresisted.

The details of construction that provide lateral strength and safety against an assumed wind pressure are of the first importance. The subject of this paper, however, suggests a further consideration of these same details of construction, assuming that they may be strained by wind pressures beyond their safe limits. If a building is never under any circumstances to fail, the problem is completely solved as soon as it is designed to stand under the assumed pressure. Assume that it may some day be brought to the point of yielding, and immediately some pertinent questions arise as to the possible results.

While the destruction and loss of the upper section of a building may be a matter of serious consideration to the owner, the disposition which a tornado would make of that section of the building may be an equally or more serious matter to the adjoining property owners. If it is impossible to foresee the extreme force of the elements, or impracticable from economic reasons to provide against them entirely, it certainly is rational to make such modifications in a design as will reduce the possible disaster and damage to a minimum. A very material increase of safety in this direction can generally be secured at a comparatively small additional expense, depending largely on the attitude of the designer to the problem. The design of a building to be subjected safely to a given wind pressure and never to any more is a definite problem involving only arbitrarily fixed working stresses. A design of that same building for the same condition of safety, but with the further recognition of the fact that it may be exposed to destructive pressures and with an effort to develop the ultimate strength and resistance of the material in the cage to resist those pressures, is a problem that will develop some additional considerations.

A destructive lateral force exerted against the upper section of the building will not be lost or dissipated, but must follow some well-defined path till it reaches the foundation. If a building is to fail laterally, then the ultimate strength of members under the action of lateral forces becomes of the first importance. Upright members are no longer simply columns, but are more properly considered as vertical beams carrying some initial load, and, viewed in that light, must have all the essential elements of a good beam. The unequal straining and successive failure of the rivets, due to their unsymmetrical distribution in the connections, may become an important element of the design when the stresses are sufficient to overcome the averaging effect of the frictional resistance. The relative values of the ultimate or elastic limit stresses may suggest details at the connections somewhat different from those indicated by the fixed ratios of assumed working stresses.

A brief analysis of possible results applied to the definite circumstances and conditions of any particular building may suggest probable failure along one or several well-defined lines, and as readily suggest modifications that will materially increase the strength of the structure, or at least define and limit the amount of destruction.

The amount of metal required for an efficient system of wind bracing is but a small part of the weight of the metal in the entire frame, and the cost of the latter is only about 10 per cent. to 20 per cent. of the expenditure for the entire building, exclusive of the site. The cost of the wind bracing can represent, therefore, only a very small proportion of the total capital invested. When it is considered that any additional metal used to strengthen the cage as a precaution against wind force is equally effective against possible damage due to earthquake shocks, or to the unequal settlement of the foundations, and is also an additional margin provided against the weakening effect of corrosion, the slight increase in cost must appear trifling as compared to the amount of the entire investment and the additional protection secured for the property.

It is somewhat unfortunate that the merits of the design of the framework are not so readily apparent to the investor, and that this part of the structure is of necessity immediately covered and permanently concealed from view. If the difference in strength and security due to the construction of the frames of some of these great buildings was as generally evident as, for instance, the difference in strength due to the varying thickness of solid masonry walls was in older forms of construction, there would probably be a more general recognition on the part of the owners of the need of securing the best type of framework.

A discussion of the safety of high buildings is applicable to other high structures, such as chimneys, shot towers, water towers, etc., and suggests that the development of the cage construction in buildings to its present advanced type makes it equally available for other structures of the kind named above. Monuments built with no consideration of expense will find ample security in their weight, but for any high structure in which cost and security are both of importance, the cage type of construction is thoroughly applicable and may have special advantages. The saving of material in the walls, and particularly in the foundations, may more than equal the additional cost of the steel work when designed for the same strength and security. The objection to any open tower built of structural metal work in a city, on the score of its inherent ugli-

ness, is removed by adopting such treatment as the architects have developed in the design of high office buildings. Any shaft or high structure that has lines of stability can be readily supported on a steel cage that will not interfere with its outlines, with probably a great gain in safety.

The amount of wind pressure to be provided for in the design of high buildings will no doubt be variously estimated, depending on the weight given in the judgment of the designer and of the owner of the building to the probability of exposure to such pressures. The statistics as to the frequency of tornadoes show that the possibility of their occurrence cannot be entirely disregarded without assuming some appreciable risk. While the atmospheric conditions which are favorable to their formation are more common in some regions than others, it is impossible to feel assured of entire immunity from their occurrence in any city. Tornadoes usually occur as local manifestations accompanying severe storms of great extent. On the date of the Louisville tornado there were ten others in the four adjacent States. On April 11 and 12, 1893, there were nineteen tornadoes in ten States attending severe storms, reaching from Mississippi to Michigan. The St. Louis tornado was but one of a number accompanying a general storm that moved through Missouri and Illinois. As far as known, it was not more violent than many others that have been observed. Its great destructiveness was merely incidental to the fact that its path crossed a territory embracing a large and closely built city. It gave evidence that wind pressures existed at least equivalent to or greater than 20 pounds, 58 pounds, and 85 to 90 pounds per square foot over considerable areas. Whatever the actual distribution may have been, the effects were those of such pressures uniformly distributed over the areas of the respective structures. These pressures were measured by their results in exactly the same manner in which they are ordinarily assumed to act, with the consequent elimination of all uncertainties usually involved in readings of pressure gages or deductions from anemometer records, and they are to that extent positive and definite. In addition, there were indications that a pressure of somewhere from 20 to 40 pounds was quite general over a comparatively wide area in, or adjacent to, the path of the storm, and that the pressures at higher altitudes were more severe than those measured.

In view of these facts it appears to the author rational to assume:

First. That the safety and interests of the community and of the owner of the building require a recognition of a wind pressure of at least 30 pounds per square foot against the exposed surface of the building, with an additional local provision of 50 pounds for several stories near the top; and that this amount should be safely taken care of by some positive and definite provision in the construction of the frame.

Second. That the vast interests at stake, the amount of capital invested and the comparatively small additional expense necessary would suggest to the owner the desirability of increasing the provision to 40 pounds per square foot.

Third. That the other uncertain elements of safety due to the ultimate strength of the material, the inertia of the mass, and the bracing effect of walls and partitions, should be recognized only as providing against the uncertain and possibly higher pressure of the wind which may occur.

The chief justification of much that seems bold or questionable in the construction of some high buildings lies in the fact that, as yet, none have failed. If the safety of such great structures is to be determined entirely by the logic of the fitness of the survivor, based on a brief and favorable experience, rather than by a rigid analysis, by tried and accepted principles of engineering design, it may ultimately lead to some very deplorable results.

By such a test the little summer pavilion in Lafayette Park must take precedence over the approach to the Eads Bridge, for it survived the tornado and is standing yet.

DUSTLESS ROADBEDS.

THE West Jersey and Seashore division of the Pennsylvania Railroad system has inaugurated a new method of treating the surface of its roadbed, the object being to prevent the lifting of dust by trains. The invention, which is patented by the assistant engineer of the company, Mr. James H. Nichol, consists of the application of a heavy oil of low cost, the product of petroleum distillation. This oil being applied to the surface of the track and roadbed, including the sides of slopes in cuts, fastens the loose particles of the surface together, and prevents them being lifted by the rush of air caused by the train.

Mr. Nichol has proceeded on the theory that gravel is not only the least expensive form in which ballast may be obtained, but is also the best, provided its dust creating feature is abated. Upon the subject Mr. Nichol writes to the Railway Age as follows:

"Probably from the first building of railroads gravel such as is found along the lines of the roads has been used for ballast, and if of proper nature, porous and free from clay or loam, so as not to retain water, is one of the best substances yet used; track laid on such a foundation is elastic, therefore making the riding in cars comfortable as compared with the more rigid stone ballast. This same elasticity is a benefit to the ties and particularly to the rails, the latter, when placed on a rigid support, being in the position of a piece of metal between an anvil and a hammer, the hammer being the moving train.

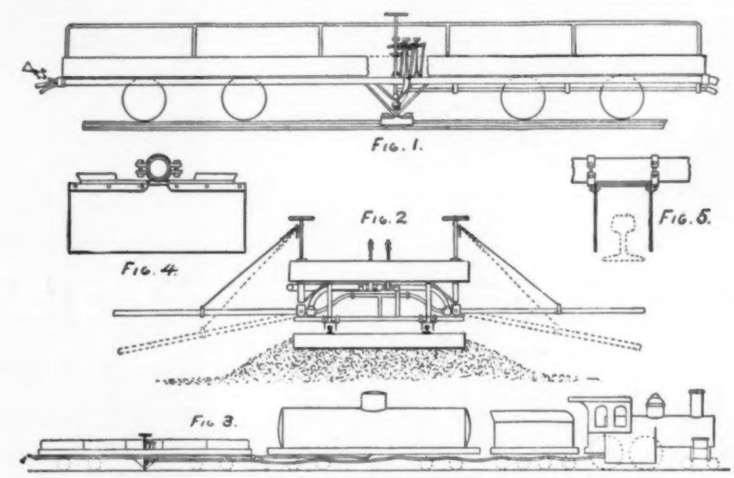
"Track laid on gravel ballast is more quickly and cheaply repaired than when on stone, the cost for ordinary maintenance and for labor in renewal of ties being about one-half.

"The principal reason for the discarding of gravel ballast on many railroads has been the discomfort to passengers arising from dust. As substitutes, various materials have been used, such as cinder from anthracite and bituminous coal, burned clay, crushed stone, etc. Each of these substances has some dust connected with its use, stone having the least. Cinder ballast is thought by some to affect injuriously the life of the cross ties, rotting the wood with which it comes in contact. Stone ballast, when first applied, and after being washed by rains, is clean and free from dust until such time as it becomes filled with material, largely cinders, thrown from the stacks of freight trains, and in this condition requires to be forked out and cleaned at large expense; the tamping of the ties, to obtain and preserve a level surface of the rails, results in the stone being crushed under the ties; and, if of a limestone character, a condition resembling a cement trough is formed under each cross tie, which catches and retains rainwater, causing the tie to decay.

"Cinder ballast, after being newly applied, requires several rainstorms to wash it free from dust, and then it is reasonably clean until the work of surfacing of track or renewing the cross ties stirs up the cinder from below the surface and exposes a new layer of dust. After a few years' use cinder becomes pulverized by repeated tampings, and is then a more objectionable dust than that from gravel, being dark in color. Experience shows that the oil produces equally good results with cinder as with gravel or sand."

The apparatus used in treating the roadbed with oil is illustrated in the accompanying engravings. For distributing the oil an ordinary flat car is fitted with one fixed pipe extending the length of the cross ties, and two swing pipes—one on each side—which, when extended, will reach two or more feet up the sides of slopes in cuts. Each pipe is controlled by a gate valve worked by a lever. A supply pipe extends the length of the car and a rubber hose connects with the four inch outlet in the ordinary tank car. A locomotive engine moves both cars and furnishes steam or compressed air to aid in ejecting the oil when thickened by cold weather. The flat car has box for tools, extra parts, etc., and is partly covered with an awning to protect the men. The sprinkling pipes are slitted for the oil to escape. The sprinkling car is furnished with shields, which cover and protect the rails from any oil which might drop or be splashed onto them. One end of the supply pipe on the sprinkling car is fitted with a connection for three or more lengths of hose, each terminating in a valve and spreader, for use by hand in covering sides of slopes in cuts.

The quantity of oil used is two thousand gallons per mile. In practice, on the West Jersey road, ordinary commercial tank cars holding six thousand gallons each are distributed at sidings about three miles apart, and are picked up as needed, the empty car being left.



OIL SPRAYING APPARATUS FOR ROADBEDS.

FIG. 1.—Sprinkling Car. FIG. 2.—End Elevation of Sprinkler. FIG. 3.—Diagram of Train. FIGS. 4 AND 5.—Details of Rail Shield.

The speed of the train at work is about four miles per hour.

In addition to the principal advantages claimed for the system, viz., the comfort of passengers and the reduction of wear and tear on bearing points of the rolling stock, the avoidance of hot boxes, etc., a point is made in regard to the preservation of ties and the general improvement of the roadbed, from the fact that rainwater is shed from the ties and ballast and runs off into the ditches instead of penetrating the ties and below the surface of the ballast. It is, therefore, expected that less labor will be required to keep the track in condition as to surface. The growth of vegetation in the ballast is also checked. The oil used is non-combustible, and has but little odor at first, and this is said to be lost on a few days' exposure.

The use of oil was commenced in April last. At the present time (August) there is something over one hundred miles of single track treated on the West Jersey and Seashore Railroad. The Philadelphia, Wilmington and Baltimore Railroad is building a sprinkling car in preparation for extended use, and beginnings have been made in the use of oil by the Philadelphia division and middle division of the Pennsylvania Railroad, also by the Amboy division of the same company.

Mr. Nichol gives the following account of the experience had with the treatment up to the present date:

"On the West Jersey and Seashore Railroad, which was the first to adopt the method, three months' exposure of track treated once shows a penetration in gravel ballast of three to four inches, being greatest where the gravel has least clay or loam in its composition. Walking on this ballast colors the sole of the shoe with oil; the ballast itself is not picked up on the shoe, but is pressed into the ballast beneath, a slight impression being made by the foot. When trains pass at speed no dust whatever is lifted, the track is not only practically dustless, but is absolutely so. The oil has penetrated the cross ties from one-eighth to one-half inch, according to the closeness of the grain of the wood. All of the ties are of oak.

"At a number of places track surfacing has been done after the application of the oil without creating dust, there having been a sufficient amount of ballast impregnated to prevent dust. This summer's experience has demonstrated that one application will last at least one season, and indefinitely thereafter or until ballast is broken up by renewals of cross ties. It is confidently expected that two or not more than three applications will suffice for years, as the ballast will be impregnated to and below the bottom of the cross ties, and renewals of the latter will not cause dust to be turned up."—The Railway Age.

[Continued from SUPPLEMENT, No. 1129, page 18047.]

THE UTILIZATION OF ALUMINUM IN THE ARTS.

ALUMINUM seems to be particularly adapted for surgical instruments and processes, and considerable has been sold for such purposes, including handles of saws, knives, speculums and surgical apparatus generally. It is not corroded by antiseptic agents. Aluminum has also been used in trachometer tubes and metal appliances placed in contact with living tissues. Someone has an aluminum blade four inches long placed in his jaw to take the place of the jaw bone. He eats as well as ever with his aluminum jaw bone.

A bicycle called the aluminum bicycle has been sold upon the market, the whole frame being cast solid in one piece, with quite a number of the parts hollow, and frames have been made of aluminum tubes brazed together by a secret process.

A good deal of talk has been made in Europe about alkolite; another alloy is romanite. All these various alloys are mainly pure aluminum, hardened with a small percentage of other ingredients, usually less than ten per cent. The composition can readily be told by analysis in most cases. Copper and nickel, while hardening aluminum to some extent, do not render it as hard as some other ingredients. Where extreme hardness is desired, zinc, manganese and titanium give much more satisfactory results, although each, unfortunately, renders the metal more brittle than does nickel or copper alone.

In Great Britain aluminum tubes are used which are drawn on mandrels and have the advantage over the worked metal in both strength and ductility.

The Pittsburg Reduction Company have orders for casting brake shoes for 80,000 bicycles; also orders for the rims of wheels for over 100,000 bicycles.

Aluminum is being used successfully for lithographic work, the light plates being used instead of the lithographic stone, as in the past.

Lithographic work has required a peculiar stone, which is only found in special places; and the stone has to be used in thicknesses of at least an inch to two inches, and the plates are very heavy and hard to manage. With the use of light aluminum plates a very much larger number of impressions are made.

For letters and signs, aluminum has become quite extensively used, not only in the shape of fine powder or bronze, but also in heavy cast letters, which can readily be attached to glass as well as wood.

Aluminum has not been used, but has been proposed for the fabrication of passenger coaches, both in the roofs and sides of cars, as well as in the fittings around the windows. Handle bars for city railway car brakes are now made of aluminum. With handle bars made of brass, the corrosion of the metal occasions sore eyes and affections of the mucous membranes, due to the poisoning action of the copper salts.

Aluminum bronze powder is finely powdered aluminum. In the cheaper varieties now sold on the markets it is adulterated often with fifty per cent. of tin. Pure aluminum, being entirely unacted upon by sulphureted hydrogen, is more durable and superior to silver powder than the article adulterated with tin. There used to be a considerable amount of silver powder used in the arts for various purposes, where now aluminum powder has entirely replaced it.

Owing to the extreme malleability and ductility of aluminum, sheets of the pure metal are now produced of only $\frac{5}{10000}$ to $\frac{1}{10000}$ of an inch in thickness.

Cast aluminum bath tubs, sinks and similar plumbers' appliances are being made.

It is used extensively for oil cups where reciprocal motions are made, the light weight being advantageous.

The use of aluminum in the galvanizing bath has become universal to produce the best and most economical grades of galvanized work. This aluminized zinc is used in such proportions that the total amount of aluminum in the bath will be only a small proportion—about 5 per cent. of aluminum to 95 per cent. of zinc in the alloy. These proportions vary according to the grade of zinc which is used; also to the class of metal to be galvanized.

Aluminum is largely used to improve the quality of brass castings. Aluminum has been added to the brass

to strengthen it, in all proportions from $\frac{1}{10}$ of one per cent. to 10 per cent., and the best results have been obtained in using aluminized zinc (first suggested by Mr. Joseph Richards).

Adding aluminum to brass mixtures has caused the brass to give dirty castings. This really means the attempt of the aluminum to purify the brass from these properties of lead and zinc. With pure, good brass, aluminum does not form this dross nor make black, unsound castings.

Used in proportions of 5 to 10 per cent. with copper, it forms aluminum bronze, one of the most dense and strong metals known.

Aluminum has been used in the construction of yachts in the sheathing of decks; for construction above the water line, for the purpose of allowing a greater sail area to be carried without a vessel becoming cranky or top heavy. The Defender has a total saving made in the use of aluminum of over seven tons, the hollow steel boom or gaff also saving another ton. The tensile strength was 40,000 pounds per square inch, the modulus of elasticity of the metal being 11,500,000 pounds. Aluminum is being used in our navy for air port shutters in bulkheads to prevent danger from shattered pieces of flying shells.

An important use of aluminum has just been started in parts of furniture. Bookcases, rat and vermin proof, have been made, and are welcomed by public librarians.

Pure aluminum has an electrical conductivity of 63 to 64 per cent., and Prof. Richards has stated that with absolutely pure aluminum a conductivity of 66 to 67 per cent. of pure copper would be obtained. It is practically non-magnetic and may be used for purposes where a magnetic metal would be useless. Already the Pittsburg Reduction Company have finished several hundred miles of wire for telegraphic work. The use of aluminum for field military telephone and telegraph wire has special advantages. Nickel aluminum castings have been made with a conductivity of 50 per cent. of pure sheet copper. The tensile strength of ordinary copper castings is 19,000 pounds per square inch, while nickel aluminum castings have been furnished with tensile strength of 30,000 pounds per square inch.

The purest aluminum we have been able to obtain was 99·93. The purity of the commercial article as ordinarily sold is 99·30. I feel safe in making the statement that a good deal of the metal being sold is 99·60. Of copper the purest that has been made was 99·95, and the purity of the commercial metal is 99·50.

Aluminum has played an important part in the cases for compressed food, not only allowing of rapid distribution of food, but also as convenient dishes in which to heat and cook the food at the time of consumption.

Tea boxes are being made out of thin aluminum sheet weighing about $\frac{7}{16}$ pound per square foot, with angles on the inside corners for holding the sheets together.

Generally speaking, for purposes where aluminum alloy is brought into requisition in sheet form or in the shape of angles, 32,000 to 40,000 pounds per square inch may be allowed, and gives an allowable working strain of from 8,000 to 10,000 pounds per square inch. The ultimate strength of the pure aluminum is 6,000 to 7,000 pounds per square inch.

Castings of aluminum can be taken at 16,000 pounds per square inch for pure aluminum and 24,000 pounds per square inch for alloys. The pure metal should not be used in castings, except for electrical purposes, as it is very difficult to cast; is soft, comparatively weak, and has a much larger shrinkage. Alloys of 5 to 20 per cent. with copper and other metals should be used.

The ratio of the ultimate shearing strength to the ultimate tensile strength, with double riveted joints, is 70 per cent., and for single riveted joints is about 60 per cent.

The attention of those contemplating the use of aluminum for structural purposes is called to the fact that the elastic limit is closer to the tensile strength than in most other metals. Where any great strength is desired, the metal should be protected so that the temperature is not raised very much beyond that of the ordinary atmospheric air, because it melts at a little below 1,200 degrees F. For temperatures between 100 and 200 degrees Centigrade, the unit of strain should be decreased.

In the purifying of water aluminum is destined to take an important part. Alum and the sulphate have been used considerably to purify water. The active principle of alum has been the hydrate of alumina. The idea is that the gelatinous hydrate of alumina can be better produced from metallic aluminum plates immersed in water. Should the process develop, as it bids fair to, there will be a very large increase of demand for alumina. The aluminum plates being used as anodes, with the electric current passing through their ends and effecting a decomposition of the water, ozone is produced, and the electrolytic action on the water and the action of some principle in the freshly precipitated hydrate of alumina take the impurities out of the water somewhat in the form of a scum, which has really only to be seen to show how rapidly and how well the operation can be conducted.

For the ordinary coinage, aluminum, in its harder alloys, seems to be particularly well adapted. Several countries, including the United States, India and several of South America, have started to investigate the merits of the aluminum alloys for the use mentioned.

Aluminum has been extensively used in brushes and combs. There are two companies making nothing but aluminum combs. In canteens, buttons, bell plates, rings for shoulder bands, scabbard handles and shoe pegs it is largely used. One advantage in the use of an aluminum shoe peg is that there is no corrosion as there is with an iron peg.

Aluminum has been used for burial cases or caskets of various kinds.

The soldering of aluminum is found a difficult task; most of the hard and soft solders will not stick, the heat rapidly vanishing from any of the molten solders, causing them to freeze before the joint can be made. Pure tin, with a little phosphor tin, is the basis of a majority of the solders. A special solder for aluminum has been made by Edwin M. Cook, not used with any flux, simply requiring the aluminum surfaces to be cleaned and then coated with the solder.

Many fluxes have been proposed in the soldering of aluminum. Common stearin, such as is used in wax candles, has been found as efficient as any of them. Special care should be taken to clean the surfaces to be soldered, which can be successfully accomplished by any mechanical means, thus exposing fresh metal surfaces freed from the thin film of oxide of aluminum and oxide of silicon. A good plan is dipping the sheets into nitric acid diluted with three times its bulk of hot water. The solution can be kept in leaden or glass lined tanks.

Aluminum is a very sonorous metal, and is used quite extensively for gongs in the place of brass.

The first uses to which aluminum was applied were naturally those which would stand the high cost of ten to fifteen dollars per ton. This was for opera glass tubes and other optical instruments, and it was then used in thin sheets; also used in powder made from the foil in a large line of fancy goods, where the proportion of the metal was a small proportion to the total cost.

A source of failure of the metal was applying it to aluminum apparatus for heavy liquids. It will not stand more than one hundred pounds per square inch without leaking—percolating through the pores of the metal. Better strengths will be made later on to stand these heavy liquid pressures.

The lecturer would not recommend the use of aluminum at 300 degrees F. This makes it impracticable for steam boilers where the pressure is high.

The importance of aluminum in industry is emphasized by its now supporting papers devoted specially to its development, chief among which in this country is the Aluminum World (published in New York City), while there are several such published abroad.

[Continued from SUPPLEMENT, No. 1128, page 18028.]

EDWARD DRINKER COPE, NATURALIST.*

IN 1886 he received an appointment to a chair in the University of Pennsylvania and became professor of geology and paleontology. Such a man naturally awakened the interest of apt pupils, and he was a facile and entertaining lecturer. From the stores of a rich memory he could improvise a discourse on almost any topic within the range of his varied studies. His views were so much in advance of those in any text book that for his own convenience, no less than for the benefit of his pupils, he felt compelled to prepare a "Syllabus of lectures on geology and paleontology," but only "Part III, Paleontology of the Vertebrata," was published. It appeared in 1891 and is still a valuable epitome of the classification of the vertebrates, recent as well as fossil, giving in dichotomous tables the essential characters of all the groups above families and also the names of all the families. His own industry and investigations did much to render this antiquated in even six years, and a new edition or work became necessary. "Upon the Tuesday preceding his death he sent to the press an elaborate outline of his university lectures, containing his latest ideas of the classification of the Vertebrata."†

The enormous mass of publications constantly flowing from his own pen might lead one unacquainted with the author to suppose that he was probably a recluse, but there were few men of his intellectuality who were less disposed to seclude themselves. He enjoyed and gave enjoyment to intellectual company and was a brilliant conversationalist. He was especially fond of academical meetings, and was an unusually frequent attendant at the meetings of the American Association as well as of the National Academy of Sciences. His election to the presidency of the American Association was highly esteemed by him, and doubtless his address would have been a notable one.

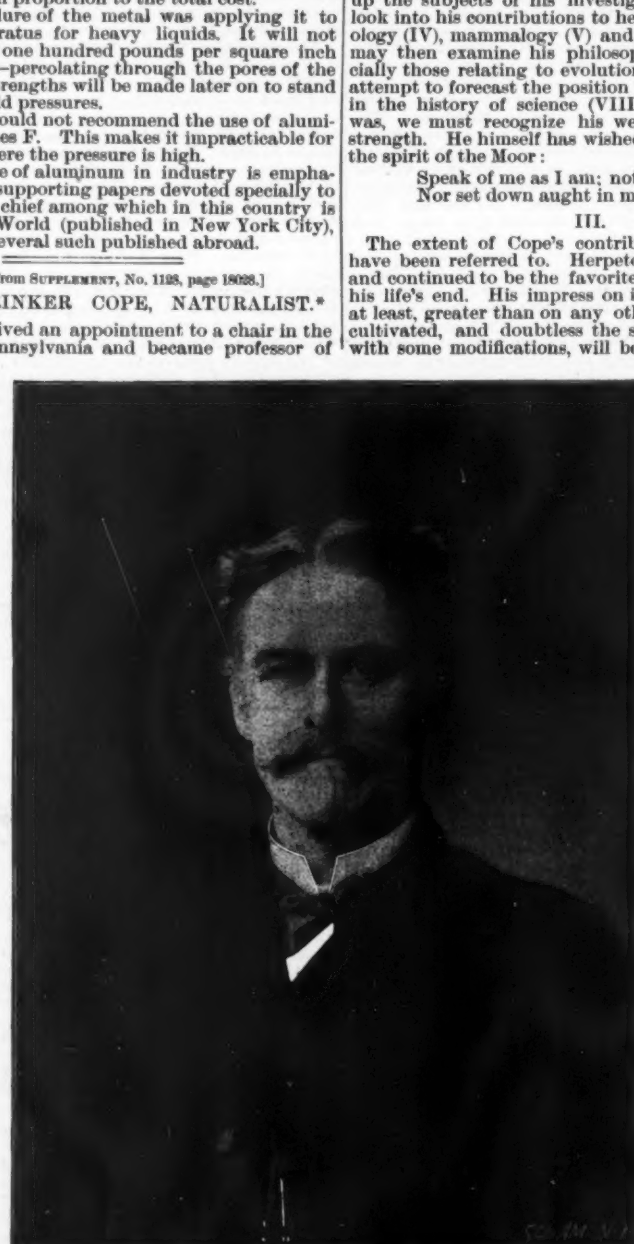
In February (1897) Cope's health became seriously affected by nephritic disorder, which, it is said, "might possibly have been remedied by a surgical operation," but this he would not submit to. Notwithstanding failing health, he continued active almost to the last. Finally the insidious disease invaded his entire system, and he died on the 12th of April, in the room he had long used as a study, surrounded by the objects of his lifelong attentions.

Such were the chief episodes of Cope's individual life; the facts known are few, and the record belongs rather to his family than to us. But Cope's real life was in his work, and to the consideration of that work we may now proceed. Let us adopt the order in which he took up the subjects of his investigations and successively look into his contributions to herpetology (III), ichthyology (IV), mammalogy (V) and paleontology (VI); we may then examine his philosophical views, and especially those relating to evolution (VII); finally we may attempt to forecast the position he is destined to enjoy in the history of science (VIII). To know him as he was, we must recognize his weakness as well as his strength. He himself has wished this and has asked in the spirit of the Moor:

> Speak of me as I am; nothing extenuate,
> Nor set down aught in malice.

III.

The extent of Cope's contributions to herpetology have been referred to. Herpetology was his first love and continued to be the favorite branch of science to his life's end. His impress on it was, in some respects at least, greater than on any other of the sciences he cultivated, and doubtless the systems he introduced, with some modifications, will be the most lasting. He found herpetology an art, he left it a science; he found it a device mainly for the naming of specimens, he left it the expression of the co-ordination of all structural features. The reformations he effected in the classification of the anurous amphibians and the saurian reptiles were especially notable.



THE LATE EDWARD DRINKER COPE.

The anurans had been chiefly differentiated in groups on account of the most superficial characters. Such were the modes of fixation of the tongue or its absence, the development of disklike expansions of the tips of the toes, or simply attenuated toes, and the presence or absence of teeth in a jaw. Cope proceeded to investigate the group in an anatomical manner and reached entirely new conclusions. He found that important differences existed in the structure of the sternum, and especially in the connection of the lateral halves. In the common toads and tree toads of Europe and North America the so-called clavicle and coracoid of each side are "connected by a longitudinal arched cartilage which overlaps that of the opposite side," while in the common frogs the clavicles and coracoids of both sides are connected by a single median cartilage. The former type is now known as the arciferous and the latter as the firmisternal. Although Cope was the first to appreciate the significance of those characters, he did not at once fully realize their morphological value, the name Arcifera having been originally applied by him only to types of that group having teeth. Ultimately he did so, and his views have stood the test of time and the latest critical investigations. He also found that the characters so revealed served to fix the places in the system of the groups in question. In their early stages the Firmisternials (or frogs and their relations) have the shoulder girdle movable, and thus resemble the Arcifers (toads, etc.), which have the opposite halves movable during their whole lifetime; thus it became evident

* Presidential address by Prof. Theodore Gill before the annual meeting of the American Association for the Advancement of Science, August 9, 1897.

† Osborn in Science, May 7, p. 705.

that the latter are the lowest or most generalized forms, and the former more advanced and higher in the system. The development of teeth, which had been supposed by the earlier systematists to be of paramount value, and which Cope, following in their footsteps, had also originally unduly valued, has been found to be of quite subordinate importance.

The lizards were also in former times distributed into families and other groups on account of variations in superficial or external characters, such as the form of the tongue, the arrangement of the scales and the development of legs and feet. Cope dissected examples of all the types he could obtain and found that such superficial characters were often misleading, and he proceeded to arrange them with reference to the preponderance of all characters. The structure of the cranium especially was analyzed, and the variations and concordances in the development of various bones were tabulated. These characters were supplemented by others derived from the vertebræ, the shoulder girdle, the teeth, the tongue and the pholidosis. Familiarity with his subject enabled him almost instinctively to assess the relative values of the different characters, and he obtained fitting equations which resulted in a system which has received the approbation of the most competent judges to the present time.

The extent of Cope's influence on herpetology may be to some extent inferred from the catalogues of the richest collection of reptiles and amphibians in existence—the British Museum's. Descriptive catalogues of both the Anurans and Saurians have been published at different times. In the early catalogues are adopted the views current at the dates of publication—1845 for the lizards; 1858 for the batrachians. New editions were published many years later, and the systems of Cope were adopted with slight modifications. In his catalogue of the Batrachia salientia, Mr. Boulenger, the author, remarked that it appeared "undeniable that the principles of classification laid down by Mr. Cope are more in accordance with the natural affinities of the genera of tailless batrachians than those employed by other authors; this is amply proved by all we know of their geographical distribution, development and physiology."

In an article* published in advance of his catalogue of the lizards, Boulenger states that the old classifications are, "on the whole, as unnatural as can be," and that, "like Cope, whose lizard families I regard as the most natural hitherto proposed, I shall lay greater stress on osteological characters and on the structure of the tongue."

It was a long time, however, before Cope's views became popular. Even anatomists of repute refused to follow him. One† of them, for example, admitted that "skeletal characters are, indeed, most valuable ones in leading us to detect the deepest and truest affinities of vertebrate animals, but [he urged] these affinities once found, it is very desirable that zoological classification should not, if it can possibly be avoided, repose upon them only, but rather on more external and more readily ascertainable characters." He therefore ventured "to propose a classification derived from that of Dr. Günther."

Cope replied* by a fierce review of the work of Dr. Günther, and concluded with the utterance that such views "will only interfere with the progress of knowledge if sincerely held and believed."

But such views were evidently sincerely believed, and they did retard the progress of science. An eminent Russian herpetologist objected to the use of anatomical characters. He especially protested against those employed by Boulenger after Cope to the grouping of the lizards, and Mr. Boulenger considered it incumbent on him to defend the practice of using such characters;† he aptly replied that the use of "purely external characters . . . does not meet the requirements of modern science," and that classifications are not made simply "for the convenience of beginners."

At last, however, the principles of classification adopted by Cope have become generally accepted, and doubtless this was in no small degree hastened by their application to all the amphibians and reptiles by Boulenger.

Cope's attention to the extinct reptiles was excited by the examination and consideration of a carboniferous lizardlike amphibian which he was requested in 1865 to report upon. It was a new species which he named Amphibamus grandiceps and considered to be the type of a new order to which the name Xenorachia was applied, but which he subsequently referred to the new comprehensive order Stegocephali.

He sought for specimens of the extinct species with as much enthusiasm as he had for the recent. Extinct and living he considered together, and light was mutually reflected from the two to guide him in the perfection of the entire system. In 1869 he gave expression to the results of his studies in a well illustrated "Synopsis of the Extinct Batrachia, Reptilia and Aves of North America." This was supplemented in 1874 by addenda and a "Catalogue of the air-breathing Vertebrata from the Coal Measures of Ohio."

A rich field was opened to him in 1877, when he received the first installment of reptilian remains from Texas, which were at first considered to be of Triassic age, but subsequently determined to be Permian.

Successive installments of amphibian as well as reptilian skeletons enriched his collection, and his investigations revealed a new and wonderful fauna rich in species and often differing widely from any previously known. These were described in many articles. The results for the amphibians were summarized in 1884 in a memoir on the "Batrachia of the Permian Period of North America."

The Permian amphibians were found to vary much in the composition of their backbones. Instead of having single centra arranged in a continuous row as in existing vertebrates, they had distinct bones on which were devolved portions of the functions fulfilled by the centra of higher vertebrates. Some had "the vertebral bodies represented by three segments each, a basal intercentrum and two lateral pleurocentra;" these were named "Ganocephali" and "Rhachitomi." Some "differ remarkably from all other Vertebrata in having between the centra another set of vertebral bodies, so that each arch has two corresponding bodies;" these were called "Embolomeri."

In tracing the development of these bones, Cope came to the conclusion that they were only partially represented in higher or more specialized types; they did not become consolidated, but one or the other became reduced and finally lost or at least greatly atrophied. In the living amphibians the vertebral centra are homologous only with the intercentra, while, on the contrary, the centra of the reptiles, birds and mammals are represented by the pleurocentra of the Rhachitomes.

(To be continued.)

* Synopsis of the families of existing Lacertilia. Ann. and Mag. Nat. Hist. (5), XIV, 117.

† Mivart in Proc. Zool. Soc., London, 1869, p. 281.

* Cope in Am. Journ. Sci. (3) I., p. 203.

† Boulenger in Ann. and Mag. Nat. Hist. (5) XIX., 385.

THE ANT EATER IN THE ZOOLOGICAL GARDEN AT STUTTGART.

The Zoological Garden at Stuttgart has for the last four years exhibited a pair of ant eaters (Myrmecophaga jubata). These are natives of South America, and belong to the family of Edentata, their jaws being quite toothless. Thanks to the great care bestowed upon them, they are in a state of splendid health, in spite of the difficulty generally experienced in keeping similar specimens long in captivity. As for breeding these animals, all attempts had proved useless until lately. But at the Stuttgart Zoological Garden, which has had similar successes before, in the way of American ostriches bred in captivity, and the pairing of a brown bear with a polar bear, there have on three occasions come into the world young ant eaters. The first comer was unexpected, and was unfortunately killed by his father. The second time they managed to keep the young animals alive for a week, and to make some observations. Once more there has been a young ant eater born, and our illustration shows him in the position he took from his birth, and kept till his untimely death—for he too was not destined to live long. He was crushed by his mother on the third day of his life.

ANT BEAR AND YOUNG AT THE ZOOLOGICAL GARDENS IN STUTTGART.

It resembled its mother in shape and color, only the fur was shorter and softer. The claws on the forefeet, the ant eater's only weapon, were already well developed, enabling the animal to climb up on its mother's back without the least difficulty. It never left that place except when the mother lay down.

Further breeding on the part of the ant eaters at Stuttgart seems within the range of possibility.

Our illustration is taken from Illustrirte Zeitung.

The use of street cars, omnibus and city railroad lines in Berlin, Germany, has considerably increased from 1895 to 1896. In 1895 some 270,000,000 odd persons were carried by the various cars; 1896 the number rose to 311,200,000 persons, the increase being over 41,000,000. The average daily total of persons using the street cars and omnibuses in 1895 was 739,862; in 1896, 850,323 persons, an increase per day of 110,461 persons.—Glaser's Annalen.

THE SCIENCE OF HUMANITY.

By W. J. McGEE.*

OF THE EXCELLENCE OF HUMANITY.

HUMANITY is a favorite theme of poet and philosopher, novelist and historian, dramatist and moralist. The changes rung on the theme run the entire gamut of human feeling and thinking; its burden is caught in song and story and crystallized in books; and no sweeter strains have ever been sung, no grander scenes enacted, no nobler lines penned, than those fertilized by the touch of human (and solely human) nature that makes the whole world kin.

The chief subject of thought among all races is humanity in some of its numberless aspects; the chief part of the literature of civilized nations relates to humanity; the chief activities of all men are inspired by humanity. Yet—and this is a modern marvel—for the greater part the thought is vague, the literature chaotic, the activity unorganized; i. e., this most important of all subjects-matter and objects-matter in human ken has hardly been brought into the domain of that definite knowledge called science. It is meet to inquire why this is so; and, to the end that the inquiry may be answered clearly, it is needful first to define humanity and then to consider what knowledge is and the way in which science has come to be; later the half formed science of that which is proper to intellectual man and most important to his kind may be outlined.

OF THE PURPORT OF HUMANITY.

According to the lexicographer, humanity denotes (1) the condition or quality of being human, (2) the character of being humane, (3) the character of being well bred, (4) mankind collectively, and (5) secular learning or literature.† The fourth of these definitions connotes man—the genus Homo, object-matter of the broad science of anthropology—viewed in a distinct way, i. e., as a mass or composite body rather than discrete individuals. The fifth definition connotes but a limited field in a vast domain, and is scholastic if not archaic; with this sense the term is chiefly used in opposition to divinity, often in the plural form (though there is good precedent for the use of this plural form in a more general and at the same time a more definite sense).‡ The first three definitions connote a wide range of attributes of man which, albeit well recognized by all intelligent people, are rarely reckoned among the objects-matter of anthropology, seldom included within the pale of science; yet it is these attributes that especially distinguish man and set him apart from the mineral, vegetable and animal worlds, and exalt him above the rocks and plants and beasts of simple nature.

Although commonplace, these definitions are worthy of careful consideration in that they summarize the substance of intelligent thought since the beginning of writing—indeed since its own beginning in the remote unwritten past—and particularly during the era of unprecedented intellectual activity and scientific progress dating from the issue of Bacon's Novum Organum; they carry the wisdom of the ages, and especially of these later days during which wisdom prevails as never before. Viewed separately or in connection with contemporary definitions relating to mankind, they indicate general (albeit vague) recognition of certain specific attributes of man, not as an animal but as an ill defined something known as a human being. When the history of thought condensed into the set phrases of the lexicographer is scanned, it is found that bitter controversy has been engendered by the diverse aspects of man as seen from opposite sides; the disputants, like the storied knights of old, have admired the object, one as silver and the other as gold, and have done doughty battle in defense of their one sided vision. The biologist, with eyes trained by observation and reason sharpened by long study of living things, sees the silvern side and sounds trumpet for man as an animal, while the litterateur and statesman and philanthropist are half dazzled by the golden glory of man as a thing supernal. The fair conclusion is that both are right as to what they see and both wrong as to what they fail to see; and in the light of this conclusion it is clear, if the general judgment of the body of thinkers is worth anything, that man has an animal basis on which a noble superstructure is borne.

The definitions of the lexicographer, who voices the thought of the world, show that among general thinkers the idea of humanity prevails over the idea of animality, while the current literature of science indicates that the idea of animality is dominant in scientific circles; indeed, some writers on anthropology, the science of man, restrict the term to knowledge of the mammalian order Bimana, a limitation excluding the essential characteristics of man as a thoughtful and emotional being and as an integral part of a collective and interdependent assemblage. Any attempt to harmonize these opposing ideas must begin with definite statement of the meaning attached to the essential term by more catholic anthropologists. So humanity may be defined, by exclusion, as the condition or quality or character of possessing attributes distinct from those of animals, vegetals, and minerals; or, by inclusion, as (1) attributes or characteristics confined to human beings, comprising (a) the condition or quality of being human, i. e., of acting, feeling and thinking after the manner of human beings, (b) the character of being humane, and (c) the character of being well bred; (2) mankind collectively; (3) secular learning and literature.

The supreme importance of humanity as thus defined is indicated by the fact that it is the foremost subject-matter of thought and speech and literature among all people, its prominence increasing from savagery through barbarism and civilization and culminating in enlightenment. The essential distinctness of humanity as thus defined appears when its serial relations to the other primary objects-matter of knowledge are considered. Just as living things rise above the mineral world by the possession of vitality, and just as animals rise above plants by the possession of motility, so do human beings rise above all other things by the possession of specific attributes rooting in mentality and maturing in the complex activities of collective life; or just as inorganic matter is the basis for the essentially distinct organic existence, so organic matter and processes form the basis for the essentially distinct superorganic activities of human existence. The importance and distinctness of humanity are indeed such that it behooves naturalists to recognize a fourth realm or world; to extend science from the great realms of the mineral, the vegetal, and the animal into the incomparably broader and richer realm of the purely human; and this extension is the chief end of modern anthropology.

OF THE QUALITY OF KNOWLEDGE.

Human knowledge is constantly increasing. The body or aggregate of knowledge is imponderable, and may not be counted or measured or weighed; yet it is an entity of prime importance and of universal recognition. Itself indefinite and varying from mind to mind, the sum of knowledge may be divided, albeit roughly, and analyzed, albeit crudely, and the days and years and centuries of its progress among men and peoples may be so studied that its tendencies and perhaps even the laws of its growth may be followed, albeit slowly and uncertainly. Although so indefinite, it is well worth while to try, and try again and still again, to analyze knowledge and trace its progress; for knowledge is the end and aim of intelligence, and human progress is measured not more by increase in knowledge of things than by increase in knowledge of knowledge.

Many students have found it convenient to divide or classify knowledge as individual and common, general and special, empiric and scientific, deductive and inductive, etc., according to the point of view; and these divisions are of use in that they represent first steps in analysis, though it is to be remembered that they are more or less vague or arbitrary, one or both. It may not be bootless slightly to extend this provisional analysis in order to trace more clearly the lines and stages in the growth of intellectual product.

For the sake of gaining clear ideas of relation, it is sometimes useful to project perception by the aid of mental imagery, and thereby to visualize the invisible in the eye of the mind. So the great aggregate of knowledge is often likened unto a numerical sum, or a reservoir or river fed by many affluents; but a better figure may be found in scientific ideation, and the imponderable body may be pictured as an indefinite nebula or plasma, constantly growing by accretion and constantly undergoing internal change. This plasma may best be portrayed as for the most part unorganized, with partially or completely organized nuclei and nodes and processes here and there; and there is a certain fitness in conceiving the organized tracts as near the surface, where the interactions between external and internal are direct and continuous. In this way the intellectual product of the world may be likened unto a nebula, a cloud gathering in a supersaturated solution, an ameba, or a brain—it may be viewed as a chaos more or less advanced on the way toward cosmos. The image is ideal; it serves merely as an aid in grasping and formulating widespread notions concerning knowledge as an illusive and intangible yet vigorously real and important something; but it is not essential to correct understanding of the main facts in the growth of knowledge.

Knowledge is born of the individual brain fertilized by indirect contact with other brains, and is given unto others with a degree of freedom varying with the disposition of the individual and the perfection of his mechanism for conveying thought—gesture, picture, speech, writing, printing; the growth of knowledge keeps even pace with the acquisition of structures and devices for its expression; and it is a pleasant and significant fact that in general the disposition to dispense knowledge grows strong and active just as the dispensing mechanism improves, though usually lagging a little behind—much as the verdure follows the vernal shower. So the stage of individual knowledge is initial, the stage of common knowledge consequent; so, also, individual knowledge is barren and unproductive until turned into the general fund to increase and multiply a hundredfold: and so, too, there is progressive growth from the initial stage of individual discovery or invention, through many ill-defined yet successively higher and higher steps, well toward the mature stage of general possession. It is needful to observe that the body of general knowledge can never quite equal the aggregate knowledge possessed by individuals; although stimulated by others, each active individual knows something more than he is able to tell, be he never so free in disposition and facile in expression; and it is the never-ending process of coining and issuing and exchanging the precious product of the cerebral crucible that gives rise to intellectual property right, and at the same time enriches the great plasma of knowledge and maintains the activity essential to its existence. It follows—and this scientific certitude may be commended to a certain class of socialistic schemers—that the relation between individual knowledge and general knowledge is asymptotic, and that although the latter constantly approaches, it never can reach the former; indeed, if general knowledge were ever to overtake individual knowledge, through suspension of the laws of intellectuality (undoubtedly immutable as those of vitality), the special province of mental activity would be annihilated and the body of knowledge would sink into quiescence—and, in the intellectual as in the vital, quiescence is death.

As knowledge is produced and given unto others the freedom of giving is governed by numberless conditions, including the perfection or imperfection of the mechanism for expression, the avidity or indifference of the chosen beneficiaries, and the price fixed by custom, and so it happens that certain discoveries and inventions are directly communicated only to limited groups of individuals, who thereby accumulate special knowledge. In this way cliques and trades and guilds arise and the germ of caste is planted. In this way too specialists grow up through the indifference of the masses and their inability to keep pace with the investigator whose energies are directed along a single line; and eventually, among the most enlightened peoples, special societies are formed for the purpose of fostering or diffusing discovery and invention, and thereby rounding out the great plasma of human knowledge. It may be noted that special knowledge is nearly as barren and unproductive as individual knowledge, and is soon blasted by the poison of its own egoism, unless the richer part of its substance is guided toward the general mass—to do work as it advances; for it is by no means to be forgotten that the activity of the great body of knowledge culminates in the province or zone of special knowledge, and that herein lies the leaven that leavens the whole.

During recent centuries, and especially during recent decades, specialists engaged in creating knowledge have studied knowledge itself, in the hope of learning its nature and origin; and most of these students have become convinced that the basis of real knowledge is found in the facts of the cosmos as revealed by observation or established by experimentation. So the acquisition of knowledge begins with noting particular facts and advances to assembling or grouping these facts, i. e., proceeds from observation to generalization; the second process involves the elimination of the unlike or incongruous, and this leads to discrimination and to the recognition of analogies. In general terms and somewhat provisionally it may be said that the analogies so recognized constitute laws of occurrence which may themselves be generalized, and that the requisite discrimination of analogies leads to the recognition of homologies, or laws of occurrence and sequence combined; the framing of analogies and homologies being legitimate inference, which develops in hypothesis and matures in theory or doctrine to be finally formulated in laws or principles. Knowledge produced in this regular and simple manner is commonly called inductive, though there is always a deductive element coming over from that general intellectual possession by which even the closest specialist is guided in greater or less measure. Now it is to be noted that acquisition of knowledge is largely spontaneous and unconscious—that apperception lags far behind perception, and that only the adolescent and mature among men and peoples are clearly conscious of their own mental processes, or indeed of the existence of mental process; it follows that most of the processes just outlined are ill recognized or not recognized at all, even by the very makers of knowledge. Moreover, the later steps in intellectual acquisition are commonly the first to be consciously noted; so that the majority of men, even unto the present day, have failed to recognize the true source of real knowledge, and have appealed to all manner of mysterious and extravagant sources for part or all of the intellectual wealth of the world; for, while the more complex processes alone were recognized, inference was exalted and observation was contemned, subtile imagining ran riot and overshadowed sober reason, and scholastic learning—which the practical makers of progress fortunately ignored or repudiated—grew into a labyrinth of deductions from vain postulates and hazy lucubrations. A new epoch dawned when Bacon formulated the inductive method—though he knew not that the method was old as the human mind and that he but recognized that which all men do, whether consciously or unconsciously. Reviewing the course of intellectual acquisition from observation through generalization and inference and theory unto laws of occurrence and sequence, knowledge may be classified by degree of development, and the simpler and more primitive (whether burdened by assumption or not) may be called empiric, while the more definitely organized product of special study may be called scientific; and remembering that the processes of acquiring knowledge are partly unconscious, that portion which is organized unconsciously may be classed as common sense or the wisdom of experience, while the consciously organized portion may be called science. This summary of the mode of organizing knowledge may be trite, yet it serves to show that the methods of the student of humanity are in nowise different from those pursued in the physical and natural sciences.

In brief, knowledge is ever passing from the individual to the common and from the special to the general, and thereby its quantity is constantly increased and its utility extended; during recent times it is passing also from the empiric to the scientific, and thereby its quality is improved and its beneficence multiplied.

OF THE RISE OF SCIENCE.

When the history of the class of knowledge called science is scanned, certain tendencies or directions of growth are perceived; and scrutiny shows that these tendencies are in harmony with the course of development of knowledge in general.

1. In general, observation and research begin with the rare or remote and proceed toward the common and the near. This tendency is revealed when the several branches of science are compared. Perhaps the oldest science is mathematics, which began before history, so that its origin is obscure and cannot certainly be traced to definite objective basis; but the nearly contemporary and closely related science of astronomy rested on observation of the celestial bodies—though the observation was long clouded by the mysticism of astrology. Then, as wits were sharpened by mathematical research and astronomical observation, exact knowledge was gradually brought down to nearer bodies and under the guidance of everyday observation; and thus the science of physics arose so gradually and inconspicuously that its early history is lost. Later shrewd hermits and beldams wrought magic by means of rare substances, and alchemy grew up; and as time passed the manipulations were extended to common things and the ban of secrecy was gradually broken, and so chemistry arose. These four branches of knowledge concerning the inorganic interacted with mutual benefit, and for several centuries constituted science, in contradistinction from the vast body of vague thought comprised in scholasticism and folklore and from the more useful body of commonplace knowledge not yet consciously organized. Still later attention was attracted by things nearer to mankind in place and character, and first plants and afterward animals were studied systematically, and botany and zoology arose; but for a long time the most attractive organisms were the unusual and therefore striking, or the specimens brought by travelers from distant lands—indeed, even during the present half century, scientific museum administrators are embarrassed by the tendency of the collector to neglect the common and collect the unusual in his own locality, and it is only within a generation or two that the ordinary plants and animals supplying mankind with food and clothing and other everyday

* Vice-presidential address before Section H of the American Association for the Advancement of Science, delivered at Detroit, August 9, 1897.

† Condensed and rearranged from the Standard and Century dictionaries.

‡ E. g., in "The Humanities," by J. W. Powell; Science, new series, vol. 1, 1895, pp. 15-18.

commodities have been subjected to scientific research. In like manner the science of geology began, soon after botany and zoology, with the study of rare minerals and the ancient rocks of remote mountains; gradually the research extended to the nearer hills and valleys and the later formations; and it is only within the present generation that the soil-making deposits on which human life so largely depends have been brought under scientific examination. Last of all the scientific research beginning with the stars and passing to minerals and plants and animals, and through the soil on which plants and animals live, reached man himself; yet the studied observation began not so much with fellow citizens or fellow subjects bound to the student by ties of consanguinity and affinity as with the abject savage or half-clad barbarian of distant lands; and even to-day, and in the most enlightened nations of the earth, the pictures brought up in most minds by the term anthropology are those of alien and inferior peoples, or of human curiosities and monstrosities exhibited in midway plaisances if not in circuses and dime museums. Even in scientific circles—yea, among those ranked as anthropologists—there are many who habitually restrict the term to the purely animal side of man, and ignore that broader and nobler side which distinguishes mankind from all other things. So, whether science be viewed in general or in detail, it is found that its progress is toward the Ego—toward the everyday and commonplace perhaps, yet ever toward the more important because the nearer, the more useful because the commoner; and the more nearly it approaches, the more clearly it is seen that science dignifies both student and object of study—that exact knowledge, with Midas touch, turns dross to gold.

2. In general, research begins with the abnormal and proceeds toward the normal. Judging from the habits of present day barbarians, among whom the tempest is studied and the zephyr ignored, the comet remembered and the planet forgotten, the pre-Chaldean astronomers based their first celestial observations on the erratic wanderers, rather than the orderly travelers of the sky; and in all ages prodigies—the bizarre and ill formed, the gigantic and dwarfish—have been the first to catch and the longest to hold attention among casual observers and specialists alike. This tendency toward noting the abnormal, like that of regarding the rare rather than the common, is the easily besetting sin of the touring naturalist and local museum collector, the joy of the unscientific and the despair of the scientific among museum administrators. Clearly seen in geology and zoology and botany as the vestige of a primitive past, this tendency to perceive only the abnormal is still strong—indeed, almost dominant—in the younger science of anthropology. To-day, distorted or wounded or cachectic skulls from the ancient ossuaries of Africa or the huacals of Peru are esteemed far above normal crania of a normal people who have, by normal activities, aided in making civilization and ennobling the world. To-day the platycnemic tibia and perforated humerus of questionable significance are exalted above the normal members occupied in the march of progress and the conquest of lower nature. To-day there are a flourishing sub-science called criminology and a fantastic fad of extolling and magnifying degeneracy, while the upright in mind and the sound in body are relatively neglected; yet this apparently morbid taste but reflects a tendency of the human mind, and is the promise of better things when the intellect, awakened by the abnormal, acquires the power of appreciating the normal.

Unremembered millenniums of mystical shamanism were required to produce pathology and therapeutics, and centuries of pathology were needed to produce sound physiology and etiology, and in like manner there were generations of mystical and irrational psychomancy before students were able to recognize a basis for the modern and most promising science of psychology. It smacks of the paradox to say that the beginning with the abnormal is the normal course in the making of science; yet the history of each and all of the sciences shows that the observation on the abnormal has always led attention to the normal, just as observation on the remote has ever guided attention toward the near; and it is but natural that the youngest of the sciences should yet retain vestiges of undue magnification of the abnormal.

3. In general, scientific determination proceeds from the qualitative to the quantitative. This tendency is displayed by every branch of science, and so conspicuously that it may be deemed characteristic. It is in accordance with this tendency that estimate precedes weighing and reconnaissance goes before surveying; and it is under the same tendency that scientific progress involves constantly increasing refinement in observation and ever-growing accuracy in definition.

4. In general, scientific interpretation proceeds from the formal to the physical,* from the material or the inert or the static to the dynamic. The positions and movements of the moon and planets were determined with fair accuracy before Newton discovered that the paths of these and all other celestial bodies are fixed by gravity; when this discovery afforded the means for determining position and movement with incomparably greater accuracy. The physical and chemical effects of heat were recognized for generations, and were ascribed to the hypothetic element phlogiston or the imaginary fluid caloric, long before Joule and others found it to be merely a manifestation of molecular motion; whereupon physics and chemistry were revolutionized and the forces of nature were gradually harnessed many times more effectively than before.

The ancients recognized vitality and ascribed it usually to a material something joined to the matter of the body. Some twenty-four centuries ago, sagacious Heraclitus conceived life as a universal fire; and less than five centuries ago Paracelsus, and after him Van Helmont, wrote of the anima mundi or archeus, having in mind a vaguely imponderable thing akin to the so-called astral body which votaries of an Oriental belief imagine themselves able to materialize out of the depths of transcendental reverie. Two centuries ago Hoffmann and other anatomists spoke habitually of the vital fluid as contemporary physicists of phlogiston, and within a hundred years leading physiologists, like Hunter, thought and wrote of the "diffused vital material." Less than a quarter of a century ago, Barker was deemed bold unto recklessness for undertaking to correlate vital and physical forces,* and many heads were shaken doubtfully when, in his presidential address before the American Association, at Boston, in 1880, the same brilliant experimentalist argued from the applications of Mosso's plethysmograph that mental force also may be weighed and measured, so that it must be regarded as interconvertible with other forms of energy;† yet half a generation of organic chemistry and physics has established these revolutionary propositions beyond peradventure, and introduced a new area of biologic research.

The tendency toward dynamic interpretation is well shown, too, in geology. In the infancy of the science, formations and the extinction of faunas were ascribed to extra-natural cataclysms, the opening of valleys and the shaping of hills to ill conceived or inconceivable catastrophies. With Lyell—a personal associate of scientific men now living—came the doctrine of uniformism, under which it is recognized that existing rains and rivers and silt-distributing waves are competent to produce the land forms and formations of the earth, provided time enough be allowed them. The present generation of geologists, beginning with Powell and including twoscore others, have scanned the pages of the Great Stone Book, so well laid open by Colorado and other rivers, and have learned to read earth history from land forms as well as formations, and have shown that at least a portion of those earth crust movements which were sheer mystery to Lyell result from the slow transfer of rock matter by the action of running water. As interpretation grew definite and the mystery of earth making dissolved, the classification gradually changed from chiefly material or static to chiefly dynamic. For a time the formations were classified by the processes of accumulation; and now the foremost geologists classify earth science primarily by the great agencies of earth making.

In anthropology, interpretation has not yet grown definite, and there are nearly as many modes of interpreting as there are men to interpret; yet, even in the short and complex history of this youngest of the sciences the general tendency appears; for the earlier classifications were based on bodily or somatic features, while the more advanced among current classifications rest either on collective attributes or on the activities of the human groups; i. e., the older classifications indicate what men are, the newer indicate what men do. Only half a generation past was it definitively suggested that human mentality is a form of energy, but already the testimony of the plethysmograph has been corroborated in so many ways and so widely extended that most scientific students of mental phenomena assume, either explicitly or implicitly, the essentially physical character of intellectual action; and in this writing it is assumed that intellectual energy is paramount, in that it is able to control other forms of energy and make conquest of nature through invention and construction, and the faculties and works of man are classified and interpreted accordingly.

So in astronomy and physics and chemistry, and equally in biology and geology, the progress of science may be measured by the ever increasing recognition of the dynamic aspect of phenomena, of the physical forces by which the material things are moved; with the recognition of inherent energy or motion, observation progresses from the merely qualitative to the quantitative, and constantly increases in refinement; and in view of this progress in other sciences, it can hardly be regarded as premature to attempt the extension of quantitative measure and dynamic interpretation to that side of anthropology which deals with the purely human attributes.

5. In general, scientific interpretation progresses from the stationary to the sequential; for the idea of action engenders the idea of succession. The Chaldean shepherd, the Egyptian soothsayer, and the Peruvian priest, like the earlier oriental astrologer, probably first took note of the celestial bodies as striking features of the cosmos, and later observed their rhythmic procession with such care that cycles were established and eclipses and other prodigies were foretold long before the true structure of the solar system was understood. These ancient observations and interpretations must have implanted that idea of the uniformity of nature which has borne so splendid fruit during the present century; the budding notion found poetic expression in pleasing fancies of firmaments of crystal and the music of the spheres; yet it was not until the germinal idea was fertilized by the Newtonian law that the marvelous measure of celestial rhythm came to be known. Led by the planless experiments of daily toil, the mechanic—forerunner of the physicist—was the next to lay hold on the notion of uniform succession; it grew with the centuries and spread into the neighboring domain of chemistry, where it vitalized the dynamic interpretation of chemic union, and aided in producing Avogadro's law, which, according to Cooke, "holds the same place in chemistry that the law of gravitation does in astronomy"‡ and forms the basis of what has justly been called the new chemistry. This law, like all others in science, afforded a means of prevision, or of presaging the unknown in terms of the known, and thus of testing its own validity; and as test followed test the idea of orderly succession grew until, with the aid of refined observation and the guidance of special experiment, it matured in the doctrine of the persistence of motion, the keynote of modern science. Here was a vantage point from which the astronomer was enabled to study the celestial bodies, especially our own sun, not merely as masses, but as chemical and physical assemblages; and so arose the line of research sometimes called celestial physics, but defined and dignified by Langley as the new astronomy,§ which has already afforded a means of analyzing the constituents and measuring the movements of several among the myriads of other suns than ours. True, each of these strides in the advance of physical science represents progressive appreciation of cosmical forces; yet still more fully do they represent progress in recognizing orderly sequence and causal succession in the movements of molar and molecular bodies.

Borrowing from physical science trenchant ideas concerning force and succession, even the earlier biologists analyzed the mechanism of living things and slowly stripped away the primitive panoply of mystery or divinity in which the infantile imagination, whether of men or races, has always enveiled vitality. Lamarck was one of the first to extend the idea of orderly succession to organisms, and although his special hypothesis of development has fallen into abeyance it has features which anthropologists do well to remember; then came patient Darwin and doughty Huxley and studious Spencer with the definite doctrine of organic evolution, which spread from man to man and from land to land, producing the greatest and quickest intellectual revolution in the history of the world. Albeit revolutionary, the Darwinian doctrine was but the biotic complement of the physical doctrine of the persistence of motion, and the two doctrines are twin buttresses on which the symmetric structure of modern science is supported. Through the later doctrine the world and the things thereof were transfigured in a new beauty and perfection, the universe was invested with a new glory, and the narrow notion of breaks in the uniform course of nature by special fiat lost hold on the scientific mind forever.

It chanced that while the ferment of evolution was still fresh, a trio of American geologists—Powell, followed by Gilbert and Dutton—entered the inspiring region traversed by Colorado canyon, and before their work was done the germ of geomorphy, or the new geology, was planted. It was realized more clearly than ever before that the hills are not everlasting but everchanging, and that the features of every landscape tell an eloquent tale of continental evolution in which competent cause and commensurate effect follow ever in ceaseless succession through the eons of earth making. The task of the geologist is not ended, indeed, is only well begun; yet here, as in other sciences, the reign of law is realized, and the day of appeal to chance is past.

When Huxley sought "Man's Place in Nature,"* and still more when Darwin traced "The Descent of Man,"† the fruitful idea of the uniformity of nature was pushed into the domain of anthropology, and has now guided for a generation those branches of the science which deal with the animal side of man; it is true that the rhythmic sequence of cause and effect has hardly been extended so far as to cover the delicate and elusive attributes of humanity, but this extension is the motive of many investigators, the aim of the present writing. Already the broad realm of humanity is fairly defined, and the distinctive form of developmental succession proper to this realm is fairly outlined, so that the distinctness of the sphere of human attributes has been made clear; for while stellar and molecular and organic development are evolutionary in that the main tendency of change is toward differentiation, the development of humanity is involutionary, in that the main tendencies are toward integration and combination. Conformably to the fundamental facts of the great realms of nature, the earlier sciences are largely, perhaps chiefly, analytic, while the science of humanity is largely, perhaps chiefly, synthetic, and its votaries seem to find reason for figuring it as the central dome crowning and conjoining the separate columns in the ideal pantheon of science. If the confidence of the votaries is just, the youngest of the sciences may be expected to repay with interest all that it received from the several branches of knowledge whence it sprang. Already, indeed, it has thrown light on the course of organic development through researches on the human body, and has begun to guide the acquisition of knowledge through researches on the human brain and its functions; already it is contributing to the physical sciences, e. g., through the refreshing Powellian doctrine of conservation, or of common persistence of motion and matter in the ultimate particle, whereby ideas concerning the mechanism of the universe would seem to be immeasurably simplified and extended; and there are other ways in which the youngest science is daily contributing to the stock of definite knowledge. Their name is legion.

So it is that science has always progressed from the rare to the common, from the remote to the near, from the abnormal to the normal, from the merely qualitative to the quantitative, from the merely material aspect to the physical aspect, from the primitive faith in fixity, to living realization of causal succession. At first sight this progress may seem puzzling, even paradoxical, yet the general course is but an expression of the order of intellectual operations pursued in scientific research. The first step is observation; it is easy when the objects observed are isolated or distinct, and increasingly difficult as the objects increase in number and similarity. The second step is generalization, which is relatively easy when the objects examined are few, relatively difficult when they are many; while the ancillary process of discrimination of the incongruous likewise grows laborious with the multiplication of objects and similarities. Accordingly it is easy to study the rare, the remote and the abnormal, and as faculty is strengthened by exercise, gradually it becomes easy to progress toward the common, the near and the normal. So also qualitative determination is easy, quantitative determination difficult—indeed, exact quantitative work is impossible without careful training, as numberless surveyors and teachers can testify. In like manner interpretation in terms of the material, coupled with appeal to the supernatural when obstacles are encountered, is relatively easy and characteristic of the indolent or immature mind, while the firm grasp of analogy and homology, and the clear recognition of energy and sequence, require both native capacity and systematic training. Accordingly scientific interpretation in terms of action and succession is the end of mental effort, and may be regarded as the highest expression of intellectuality. This correspondence between the method of research and the history of science throughout the centuries amply attests the excellence of the method. Yet it is not to be forgotten that just as intellectual grasp strengthens so interpretation is simplified, partly through the elimination of that question-begging mysticism which pervades all primitive philosophies, partly through clearer arrangement of facts and relations. And as

* As defined by Le Conte in a notable article "On the Structure and Origin of Mountains," American Journal of Science, third series, vol. xvi, 1878, page 107.

* "The Correlation of Vital and Physical Forces."—University Series, No. 2 (Van Nostrand), 1875.

† Proceedings of the American Association for the Advancement of Science. Vol. xxix, 1881, page 12 et sequentia.

‡ "The New Chemistry" (International Scientific Series, vi), 1875, p. 13.

§ "The New Astronomy," 1888, chapter 1.

* First publication in 1863.

† The first edition of this notable work appeared in 1871.

interpretation grows simple three especially noteworthy effects follow: (1.) Each step in interpretation makes the later steps easier. (2.) As the labor lightens, more energy is left for the next task, and the mind of the student pushes into new fields of study and from time to time organizes new branches of inquiry; and (3.) With each extension of inquiry mental faculty is stimulated and strengthened. These tendencies are clearly indicated by the birth and growth of new sciences recorded in the history of research; beginning with the celestial bodies, it has extended to mechanical bodies, vegetals, animals, the earth itself, then to the human body, individual and collective; and now it is reaching out toward the special attributes of mankind, the things nearest to human welfare and happiness.

(To be continued.)

SELECTED FORMULÆ.

Depilatory.—

(1.)	Sodium sulphydrate	100 grains.
	Slaked lime	80 "
	Starch	20 "
	Lime water	4 fl. dr.

With the aid of water this powder is converted into a soft paste, and applied to a hairy skin in a layer as thick as a straw. After drying about ten minutes, the pellicle is scraped off with a paper knife, or similar blunt instrument, and with it the hair. The face should be washed clean and anointed with some bland oil.

Sodium sulphydrate is prepared by supersaturating at ordinary temperature a solution of sodium hydrate of specific gravity 1·35 (made from 1 av. ounce of caustic soda and 2 fluid ounces of water), and then setting aside the well closed jar for several days in a cold, dark place, when the crystals formed may be removed and preserved in a well closed vial, protected from the light.

(2.)	Orpiment	1 part.
	Slaked lime	5 "
	Starch	3 "
(3.)	Quicklime	120 grains.
	Sodium sulphide	240 "
	Starch	80 "
	Orris root, powder	40 "

Rub the necessary portion of this powder into a thin paste with water, and apply as directed for No. 1. —Pharmaceutical Era.

Cholera and Diarrhea Remedies.—We give below a number of desirable formulas from which you may select one or more to suit your needs:

SUN CHOLERA MIXTURE.

Tincture of opium	1 part.
Tincture capsicum	1 "
Tincture rhubarb	1 "
Spirit camphor	1 "
Spirit peppermint	1 "

SQUIBB'S DIARRHEA MIXTURE.

Tincture opium	40 parts.
Tincture capsicum	40 "
Spirit camphor	40 "
Chloroform	15 "
Alcohol	65 "

AROMATIC RHUBARB.

Cinnamon, ground	8 parts.
Rhubarb	8 "
Calumba	4 "
Saffron	1 "
Powdered opium	2 "
Oil peppermint	5 "
Alcohol	q. s. ad 100 "

Macerate the ground drugs with 75 parts alcohol in a closely covered percolator for several days, then allow percolation to proceed, using sufficient alcohol to obtain 95 parts of percolate. In percolate dissolve the oil of peppermint.

RHUBARB AND CAMPHOR.

Tincture capsicum	2 ounces.
Tincture opium	2 "
Tincture camphor	3 "
Tincture catechu	4 "
Tincture rhubarb	4 "
Spirit peppermint	4 "

BLACKBERRY CORDIAL.

Blackberry juice	1875 c. c.
Cinnamon, ground	100 grms.
Cloves, ground	25 "
Nutmeg, ground	25 "
Diluted alcohol	q. s.
Sirup	1875 c. c.

Percolate the ground drug with diluted alcohol to obtain 1,250 c. c. of tincture, and to this add the blackberry juice; then add 30 grm. purified talcum, set the mixture aside for 24 hours, and filter. Wash the filter with sufficient diluted alcohol to obtain 3,125 c. c. of filtrate and add the sirup.

BLACKBERRY MIXTURE.

Fluid extract blackberry root	2 pints.
Fluid ginger, soluble	5 1-3 ounces.
Fluid catechu	5 1-3 "
Fluid opium for tincture	160 minims.
Brandy	8 ounces.
Sugar	4 pounds.
Essence cloves	256 minims.
Essence cinnamon	256 "
Chloroform	128 "
Alcohol (25 per cent.)	q. s. ad 1 gallon.

—Pharmaceutical Era.

Wild Cherry Phosphate.—

Simple sirup	5 pints.
Fine sherry wine	2 "
Depurated German cherry juice	10 ounces.
Fluid extract wild cherry	3 "
Solution of phosphates	2 "
Fruit acid	1 "

Mix well together and filter.

For dispensing, draw a tumbler seven-eighths full with soda water; then add two ounces of this sirup, stir with spoon and serve.—Practical Druggist.

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